



FOCUS

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opportunities and developments

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By Robin King and Sally Male

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Engineering students at the University of Technology, Sydney, on a construction site visit.

Improving industry engagement for better engineering degrees

Engineering faculties agree broadly with employers that their students should gain knowledge and real-life experience of engineering practice before they graduate.

Work-integrated learning (WIL) is currently being promoted strongly within higher education. Universities

Australia recently joined with several peak business groups to promote WIL for improving the work-readiness of university graduates from all disciplines and expanding their job opportunities, as well as enhancing outcomes for employers.

The Australian Chief Scientist has also been promoting WIL for all science, technology, engineering and mathematics (STEM) disciplines, building on the long experience of WIL in engineering degrees, and the growing activities of WIL in ICT disciplines.

The Australian Workforce and Productivity Agency also sees WIL as a key element for enhancing the future skills required of graduates in both engineering and ICT.

This article describes current work to improve industry engagement in

Australian 'formative' engineering degrees that qualify graduates for commencement of supervised practice.

While the engineering profession generally values including engineering practice within these degrees, the implementation of such practice has been quite variable, in Australia and elsewhere.

During the latter half of the 20th century, the focus and content of engineering degrees progressively emphasised engineering science somewhat at the expense of its connections to engineering practice. Worldwide, there has been increased realisation that engineering application and practice skills need to be nurtured in students to improve their understanding of engineering science and to prepare them for employment.

Engineering educators have been strong protagonists of clearer expressions of 'graduate attributes', expressed in the curriculum as program graduate outcomes, and realised by student-centred and active pedagogies, particularly projects.

The Australian position on industry engagement for engineering students has long been reasonably balanced, pragmatic and collaborative – the engineering faculties agree broadly with employers that their students should gain knowledge and real-life experience of engineering practice before they graduate.

Industry experience is expected to round out and contextualise students' engineering science and application knowledge and experience, and assists their preparation for supervised practice, as graduate employees. Many employers have supported cooperative education schemes and scholarships for selected students, with educational and prospective benefits to them and the employers.

'Exposure to professional practice' is included in the criteria for program accreditation by Engineers Australia. The requirement is enshrined in most universities' program regulations, most commonly by specifying that students

must gain at least 12 weeks' experience in industry, ideally before they take their final year of academic work.

The 35 Australian universities that operate accredited engineering degrees thus have to provide exposure to engineering practice to ALL of their students (including the one-third who are international) by this, and other methods, such as guest lectures, site visits, and industry-based capstone projects. Each university is also required to have industry involvement in curriculum revision and delivery.

There are many examples of good practice in a range of aspects of industry engagement. Students and graduates report that good industry experience is transformative to their engineering thinking and prospective careers.

Alongside the good practice, there is also evidence of uneven provision and relatively poor outcomes. These may exacerbate employers' criticisms of engineering (and other) graduates as having poor employability skills. We estimate that, nationally, approximately 30 per cent of final year students have

to delay their placement until after completion of the academic requirements for graduation. There may also be weak integration of industry practice and learning within the academic curriculum.

The growth of engineering enrolments, which now produces more than 11,000 graduates each year, presents a challenge of scale.

Changes in the structure of the engineering industry present challenges in the provision of engineering placements and other activities by firms and engineers.

Finally, the general reduction of contemporary engineering practice experience (other than in research) amongst the academic workforce presents challenges in coverage, quality and assessment (by the universities) of students' experience of industry engagement.

Some of these challenges are currently being addressed in the two-year national project led by the authors, on behalf of the Australian Council of Engineering Deans (ACED), and now nearing completion.

The original impetus for the project was concern about engineering skills shortages

for the recent resources and resources construction boom. The industry-based National Resources Sector Workforce Strategy Taskforce (NRSWST) urged ACED to explore how student retention and graduation rates could be increased by stronger industry engagement, particularly in the early years of engineering degree programs. The project is funded by the former government's Workplace Innovation Program, and involves 12 of ACED's member universities and support from Engineers Australia, several industry peak bodies and employers.

The first theme of the project has explored, and partially tested and evaluated, principles and guidelines for effective industry engagement throughout engineering degrees. This work has been research-based and strongly consultative. Findings have reinforced the value to students and employers of a strong academic/industry nexus.

A report, *Best Practice Guidelines for Effective Industry Engagement*, proposes that engineering practice (including research)

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coretext
CONTENT MATTERS

should be placed at the centre of curriculum design and delivery, and that students should be encouraged, from the start of their studies, to develop their identities and self-efficacy as 'student engineers'.

A further element of the vision is that students will better comprehend engineering as a socio-technical activity, and that this can best be realised by engagement with practice and practitioners. The Guidelines elaborate on these areas for curriculum design and implementation, provide exemplars of good practice in many aspects of industry engagement, and include recommendations for improvement for the faculties, industry, and industry and professional bodies.

Bringing industry and practising engineers into the classroom is seen to be as important as providing individual students with good in-industry placements, not least because the latter cannot possibly cover all the aspects. Opportunities should also be made for students to learn from each other, in facilitated post-placement debriefs.

As part of this theme of the project, faculties have self-tested their own programs against a set of features to identify areas of strength and gaps in their own industry-engagement vision and performance. The faculties and employers have provided exemplars of industry-based design project specifications, engineering practice handbooks (including preparation and assessment) and mentoring.

These resources, the Guidelines, and other project materials are on the academic resources website for Engineering and ICT (www.arneia.edu.au).

The engineering community is already moving ahead in two areas of the recommendations:

- a national online resource to put students in contact with employers willing to offer industry placements has recently been launched by Engineers Australia, as EA Connect; and
- ACED has set up a group to scope an 'e-portfolio' self-reflection tool for engineering students to track

their progressive attainment of Engineers Australia's accreditation graduate attributes in knowledge, engineering application and personal and professional skills.

These two measures alone should contribute to improving graduate employability.

In the second theme of the NRSWST project, seven universities have developed, implemented and tested 'industry-inspired' projects. These have been selected by each university to demonstrate how current industry practice relates to what many students see as highly 'theoretical' or somewhat disconnected curriculum topics, mostly in the middle two years of the professional engineering program, where the emphasis on engineering science is greatest.

These projects have been embedded in existing course units in:

- mechanics of solids;
- electrical power systems analysis and design;
- engineering dynamics;
- fluid dynamics;
- risk, reliability and safety; and
- project engineering.

Some 30 engineering companies and local authorities have been involved in the project development, and more than 1000 students have taken the course units with the projects over the past year, some in very large classes.

In course evaluations, students have provided suitably positive responses to having these projects in what otherwise might be 'dry' units. The ongoing challenges are to package the projects into resources that can be used by others, while also keeping them up to date.

What the exercise has found, however, is willingness by companies and engineers to share non-critical materials and data, and spend time in the classroom. Academics have demonstrated that for development of a new initiative, a small earmarked grant is desirable, as well as some adaptability to build it into existing

course units, at fairly short notice.

ACED is committed to disseminate the outcomes of the NRSWST project to all its member faculties, and track aggregate retention rates and graduate outcomes. Improved industry engagement within degrees can reasonably be expected to improve these metrics, although many other factors are at play.

ACED is working with the academic community – (particularly the Australasian Association for Engineering Education), Engineers Australia and industry bodies – to underpin improvements in educational practice, on all fronts.

Together with ATSE and others, these organisations have delivered projects and arguments for change and improvement in engineering education. Having all the STEM disciplines in higher education working in similarly collaborative ways should surely improve the attractiveness of STEM degrees and improve their graduates' prospects in employment.

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**CONTRIBUTIONS
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Opinion pieces on technological science and related topics, preferably between 600 and 1400 words, will be considered for publication.

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By John Loughran
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STEM has a new meaning when it's seen in everything

Topics took on new meaning and STEM was seen in everything rather than as a single, distinct, separate and static subject that 'had to be delivered'.

The place of STEM in schools continually attracts attention. Typically issues around content and pedagogy surface in different ways, dependent on the school level – primary or secondary.

Primary teachers tend to be viewed as lacking sufficient content knowledge to confidently teach STEM, while secondary teachers are seen as being 'content-heavy'.

Combined, these views create an impression of STEM teaching in school as being less than engaging and, with the proliferation of International Assessment regimes designed to measure and rank learning outcomes, calls continually surface for the 'situation to be fixed'.

In a recent project on scientific literacy I saw first-hand how teachers can work to enhance students' learning in ways that challenge some of the stereotypes of STEM teaching and learning in schools and offer a different way of thinking about what it means to 'fix' the situation.

The teachers documented their work in detail through a book titled *Scientific literacy under the microscope: A whole-school approach to science teaching and learning* (Dordrecht: Sense publishers).

A primary school that had been involved in an ongoing science teaching and learning (STaL) professional development program made a commitment to enrol all of its staff in the program over a number of years to develop a shared vision for STEM teaching in the school.

When most of the staff had completed the STaL program, together they decided to take their learning a step further. They decided to develop an all-school, multi-domain inquiry approach to curriculum planning, designed to foster meaningful links across curriculum areas in order to enhance students' learning across subject areas.



Getting to grips with reality in STEM education – a student testing traction for different types of tyres.

STEM is the acronym for Science, Technology, Engineering and Maths in the education system.

In collaboration with the Catholic Education Office (Melbourne), the school was able to employ a 'Critical Friend' from the STaL program to support this school-based (and designed) professional learning project.

The idea of a Critical Friend was based around providing specific planning support for teachers across all levels within the school. Specifically, the role was about building the decision-making capacity of teachers and focusing their conversations on the development of key thinking and communication skills and STEM concepts that might support students in developing their scientific literacy.

The approach was based on thinking about topics in different ways and from different teaching and learning perspectives, rather than viewing teaching solely from a particular content area.

For both the teachers and the students there was a shift in thinking that led them to seeing topics as all having a STEM base. For example, topics included the place of STEM in technology, sustainability, the human body and so on. Topics took on new meaning through this way of thinking and, as a consequence, STEM was seen in everything rather than as a single, distinct, separate and static subject that 'had to be delivered'.

This shift in thinking was developed through the school's Teaching and Learning Coordinator in collaboration with the Critical Friend, who explicitly supported the classroom teachers. Through

that support teachers became more expert at articulating their pedagogical reasoning as they responded to changes in their students' learning, which led to the opening up of STEM as more than just content or process and seeing it as an important feature in everyday life.

The process that they developed was to initially immerse students in the general theme of the topic for the term. That included having students being involved in reading and internet research time, comprehension tasks, viewing of videos and clips, and a lot of work with graphic organisers and thinking tools to get them thinking about the

direction the topic might take – and that had a positive impact on teachers' understanding of STEM as well.

Although the learning activities were usually set and run by the class teacher, they were facilitated through students working in groups to brainstorm ideas and develop a workable aim for an ongoing project.

The teachers documented their work in detail through a book titled *Scientific literacy under the microscope: A whole-school approach to science teaching and learning* (Dordrecht: Sense publishers).



Students take their investigations outdoors.

For example, one aim in a unit developed by a group of students was: *To investigate sustainable practice and implement ideas that can help our school and local community become a more environmentally friendly place and to investigate the relationships that develop out of consumers' choice and the personal, social, environmental and economic impact that choice has.*

Through this aim (or focus) one group of students chose to investigate the effects of antiperspirant deodorants while another group worked on tyres, as the members had an interest in cars. Another group chose to study the impact of book production.

Each of these groups, though diverse in their topic choice, was able to identify the relationship that buying a product had on their world

and the community around them.

When their inquiry was complete, students needed to decide on a mode of presentation to share their learning with others and open their work to critique and review. Another aspect of the multi-domain approach was to invite parents into the classroom through what became

known as 'open sessions'. Through that approach students had the opportunity to model and talk about their work to parents and other members of the community and to have the satisfaction of showing off their work in ways that went beyond normal teacher-student presentations.

A great outcome of this approach was that parents and others in the community saw how scientific literacy was impacting the learning of these students. It gave an explicit example of the change in the teaching of STEM based on students learning to make informed decisions about the influence of things happening in the world around them.

A common learning outcome of the teachers involved in this project was the realisation that knowledge of STEM alone is not sufficient – that students need to be able to identify its existence in the world around them, analyse it, critique it and challenge it.

In so doing, STEM was no longer 'just another subject at school'.

Most teachers came to see STEM as dynamic through the multi-domain approach. It broadened their teaching and enhanced their students' learning in ways that were not driven by a need to be more content-based or less pedagogically pampered.

Rather, STEM teaching and learning became purposeful and meaningful through an invitation to inquiry, curiosity, creativity and meaning in the world around them.

Links to ATSE

It is interesting to consider this example of STEM teaching and learning and how it relates to the ATSE recommendation that "Governments should commit to increasing the amount of time spent

teaching quality STEM subjects in our schools" (Science and Technology Action Statement, September 2013).

This example of success in STEM highlights the need to think about STEM teaching as integrated, meaningful, applicable and relevant to students.

It is important that the ATSE recommendation and ways of interpreting it are not simplified to 'just teaching STEM'. As the example above illustrates, thoughtful approaches to teaching require much more than subject matter knowledge alone.

As is increasingly obvious from education efforts around the globe, bringing STEM into the classroom is crucial – and innovative and engaging approaches matter in encouraging student learning in ways that make a difference. That is certainly how we would want STEM to be understood by our students.

Now is a time for engineering, technology and education to be more closely aligned (at Monash we have double degrees that do this) so that STEM teaching can be seen as a career in its own right.

One way of doing this is to introduce school STEM cooperative electives in engineering and technology degrees.

Imagine how powerful it would be for undergraduate STEM students to have the opportunity to put their developing knowledge into practice with school students. Their impact on young minds could be strong and the influence on their own thinking about a career could be powerful.

Now that would be a change for the better.

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By Leon Sterling

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ICT underpins everything but we have issues in ICT education

ICT is not a well-defined term but it has been extraordinarily successful in touching all aspects of society.

PHOTO: ISTOCK

Information and communications technology (ICT) touches all aspects of society and our modern lives, underpinning everything we do. Yet its success – its rapid evolution and universal application – create distinct challenges for ICT education.

ICT is not a well-defined term. The ICT acronym is not consistently used. Some people prefer 'communication' to 'communications', or 'technologies' to 'technology', or refer to it as just IT, 'information technology'. These differences are not important.

Different people talk about ICT education with different ideas in mind, such as education in basic computer literacy, networks and computing infrastructure, skills in a programming language, knowledge of a software application or networking configuration, or concepts in computer science.

ICT is taught by a broad church, including industries giving certification, vocational education and, of course, universities.

Around 2000 I attended a keynote talk at a conference of Heads of US Computer Science departments given by William Wulf, formerly president of the US National Academy of Engineering. He pointed out that ICT suffers from being commonly associated with three very different components – infrastructure, skills and concepts. People providing support for one of these three components often feel that they are supporting ICT in general, whereas providing support for ICT infrastructure does very little to help computer science research, for example.

Dr Wulf claimed that ICT was almost unique in the extent of the confusion – 15 years later the situation has only slightly improved.

A factor contributing to confusion is that ICT has been extraordinarily successful



ICT is a world of constant change.

in touching all aspects of society. ICT now underpins everything. There is no discipline that does not use computers or does not need to consider data and the internet.

Furthermore, hardware and software have developed rapidly, with new devices and applications that become almost immediately essential in our lives. Five years ago there were no iPads or similar tablets, for example. Only 10 years ago, Facebook was created and subsequently attracted more than one billion users in less than a decade. Browsers for the World Wide Web were created 20 years ago, and the PC appeared just over 30 years ago.

The rapid evolution of technology and the ubiquity of ICT poses challenges for ICT education. There are essentially two questions: what should be taught in an ICT education and who should teach it?

The former question gives rise to concerns as to how quickly content should change, what technology should be used, and how closely ICT education should reflect modern industry practice.

This article makes some observations based on 30 years of university teaching in ICT and working at the university/industry interface.

A first observation is that universities and vocational education providers are not well placed to change rapidly.

Consider the many new recent developments in areas such as mobile application development, cloud technology, security, agile software development and new programming languages. There are new issues to master, such as understanding the recent heartbleed security flaw.

At least two factors make it hard for education providers to respond rapidly. Many essential regulations and quality assurance activities governing the work of education providers work against agility. Specifically, developing a new course focusing on a new technology typically has a two-year lead time, and by the time graduates are produced three years later, the technology has been

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replaced by something else. Introducing individual units is quicker but still takes a year or two to produce graduates.

The second factor is the lack of agility of teaching staff. Teaching staff need time to learn a new technology to a depth sufficient to be able to teach it. Time away from other duties is not easily available in the education system. Furthermore, time developing new teaching units is often under-appreciated in promotions processes and other activities. The situation is even harder at school level, where the currency of teachers is severely lacking. It is ironic that the very success of ICT causes so many problems.

Another challenge is what to name degrees in order to reflect currency. Names go in and out of fashion. Often names are floated in a short cycle. The Victorian Chief Technology Advocate has suggested the name 'Business technology' replace ICT, but in my experience that name would not resonate with students, nor does it reflect the broad range of ICT applications.

The ubiquity of ICT poses a different challenge. It is difficult in universities to have a discipline underlie a whole curriculum without fiefdom and territory disputes. Each faculty wants to teach units that are likely to draw students. There are not good mechanisms for ensuring qualified staff teach in a coordinated approach across the university.

Yet student needs come from across all disciplines. Recently, I toured a modern radio station and our host said: "I studied journalism because I wanted a career in radio broadcasting. I now realise that it would have been much more useful if I had studied ICT!"

A key responsibility of my new role at Swinburne University of Technology as Pro-Vice-Chancellor (Digital Frontiers) aims to ensure ICT is coordinated across the whole university.

Another observation is that universities and industry struggle to stay aligned. Their needs can be at odds. Employers often want training on a particular product that they use, whereas universities are concerned to teach general principles.

At a forum I attended, a games developer unreasonably criticised the university sector for not instantly teaching students about the latest game platform.

Perhaps this indicates that industry should be more involved in teaching students, albeit within currently approved curricula.

One industry group – the vendors – wants universities to lock into a particular set of products so that graduates continue to work on the products. Universities, on the other hand, prefer to expose students to a range of products. Industry certification has been one response from big vendors. The two best-known certifications come from Microsoft and Cisco. How to include such material in courses has been a challenge, but a way to coexist has been found.

How do we ensure that ICT education reflects industrial practice? It is hard to circumscribe current practice so as to know what to teach. Some companies are at the leading edge, others have outmoded practices. Graduates need to adapt effectively to both environments.

Universities tend to cover fundamental principles, an approach easy to justify, and popular among teaching staff anxious for more time for research. However exposure to what industry is doing is important, and unfortunately, exposure to industry does not happen often enough in Australian ICT education.

Agile development, now popular in industry, has struggled to become mainstream in teaching.

One way universities and industry can cooperate is through industry-based learning (IBL), acknowledged as very valuable. However, IBL is expensive to run, more so than regular courses, and doesn't scale easily if numbers in a course increase. It is also vulnerable to standardisation of university processes and fluctuations in the economy.

Explaining one's teaching philosophy builds understanding. In the Bachelor of Computer Science at the University of Melbourne, four different programming languages were taught in four programming units in the first four semesters of the course, and two of those were not commonly used in industry.

Students objected initially, but stopped complaining once they realised they had gained the ability to learn new languages. The ability to learn was essential for industry projects in the later years of the course, when often the industry client would mandate an unfamiliar language. Project plans routinely allocated time for

team members to learn the language.

Equally, industry supported the course outcomes. Nevertheless job advertisements often emphasise particular languages over generic skills such as adaptability.

The rapid appearance of new ICT technologies challenges society as to how to ensure a supply of suitably trained workers. Many industries have been reluctant to retrain workers in the new technologies in the hope that others will provide the training.

There have also been large numbers of 457 visas for ICT workers at the same time as people with older ICT skills are losing their jobs. As a result there has been mixed messages as to whether there is a shortage of ICT skills in Australia.

To conclude on a positive note, let me talk of the new-found cooperation between industry, government and universities to address perceived ICT skills shortages, improve the quality and relevance of ICT education, and encourage more students to undertake ICT units and courses at schools and universities.

There is a new national high school curriculum in digital technologies, developed by the Australian Curriculum, Assessment and Reporting Authority (ACARA), which is a significant improvement on what has gone before.

Companies such as Google and Westpac are investing in materials to train teachers.

Last year the Government funded a three-year, \$6 million program to promote digital careers.

So the future looks rosy for ICT education, although a lot of work will be required to ensure that the new-found cooperation remains cohesive.

PROFESSOR LEON STERLING is Pro-Vice-Chancellor (Digital Frontiers) at Swinburne University of Technology in Melbourne. Leon received a BSc (Hons) from the University of Melbourne and a PhD in Pure Mathematics from the Australian National University. He has worked at universities in the UK, Israel, the US and Australia. His teaching and research specialties are software engineering, artificial intelligence and logic programming. Prior to this role, He was Professor of Software Innovation and Engineering and Director of e-Research at the University of Melbourne, and Dean of Information and Communication Technologies at Swinburne. He is President of the Australian Council of Deans of ICT.



By John Beynon

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Engineering education needs an international dimension

For many universities around the world, particularly in the developed world, better education with fewer and often different resources has become the dominant conversation.

All countries need better-educated engineers and more of them. Their education needs to cover the fundamentals as well as the latest technical developments and it needs to develop the attributes the graduates will need for working in the modern workplace, which is international in so many ways.

This means that universities need to incorporate international dimensions into their programs to better prepare their students.

This applies equally to engineers in the developed and developing world, despite their different resources. Engineers everywhere need to be well qualified and capable.

Last October I became Chair of the Global Engineering Deans Council (GEDC), an international network of engineering faculty deans designed to leverage the collective strengths of the deans for the advancement of engineering education, research and service to the global community.

Although it was originally perceived primarily as a network of deans, the membership has grown to include a wide range of corporate members and we have a growing involvement with intergovernmental bodies. The expansion of our activities has produced a dramatic growth in membership, with individual deans now outnumbered by national and regional chapters, the most recent of which is from Nigeria.

There are two broad agendas in international engineering education, one for the developed and one for the developing world. However, both share the desire and need to produce graduates and, subsequently, practising engineers who are capable of developing and running our technologies. Every country basically needs the same type of engineering education.

In the developed world, discussion of a good engineering education revolves around the balance of technical knowledge and general attributes, both of which must incorporate the international environment that so many engineers need to operate within, be it in working with their clients or suppliers, or both.

This has resulted in a range of studies on the ideal output of an engineering course, with perhaps the most comprehensive being a joint effort led by the American Society of Engineering Education and supported by the International Federation of Engineering Education Societies and GEDC under the title 'Attributes of a Global Engineer'.

This statement of attributes has been produced by a team of education specialists and large companies, led by Boeing, which employ many engineering graduates each year. Such a statement is a good starting place for any university department to plan its undergraduate engineering program.

As for the output of these programs, the internationally calibrated accreditation processes provide a thorough test of quality, with the main measures nowadays being on the outcomes of the education being assessed, rather than being prescriptive about how the education was delivered. Accreditation is also growing because of its value in the design of programs and in assuring the quality of delivery.

How these programs are delivered is a major source of debate within universities, both in response to the dramatic growth in educational technologies that are available, but also with the growing pressures on the curriculum, as more content should be included and less taken out.

For many universities around the world, particularly in the developed world, this has become the dominant conversation – better education with

fewer and often different resources.

But if these countries think they are struggling for resources, the challenges faced in developing countries are much tougher. In many poorer countries all aspects of a good program are in short supply – qualified academic staff, good laboratory facilities, a strong interface with industry and, critically, a deep pool of potential students who are well prepared for an engineering education.

To try to help, GEDC has begun discussions with the World Bank and the Organization of American States to provide support for their programs aimed at assisting the development of engineering education around the world, and in the poorer parts in particular.

For instance, the World Bank started the Technical/Engineering Education Quality Improvement Project (TEQIP) in India in 2002, the first phase of which cost more than US\$300 million and closed in 2009. Phase 2 is funded at a similar level and was launched in 2010.

Phase 1 supported more than 100 institutions and thousands of faculty members in well-performing institutions and had a considerable impact on quality of education by implementing institutional and policy reforms. TEQIP's second phase addresses the supply of qualified academic staff and producing more research and development in collaboration with industry.

An interesting thrust of this work is to increase the degree of autonomy for institutions because this has been shown to encourage academic staff to teach students the skills that corporate India demands, in particular problem-solving skills, creativity and flexibility, which in turn enhances the quality of education.

GEDC is working with the World Bank to plan a conference in Bangalore in early 2015 that will include Indian

governmental leaders, policymakers, GEDC members and corporate leaders to develop the next stages of improvement in engineering education in India.

GEDC is also exploring with the World Bank the use of GEDC's network, particularly the various diaspora around the world, to help work with their original homelands, such as in Africa or Asia, to further the development of engineering education there. GEDC also provides experts to advise on matters such as accreditation and online education, usually from countries relatively nearby.

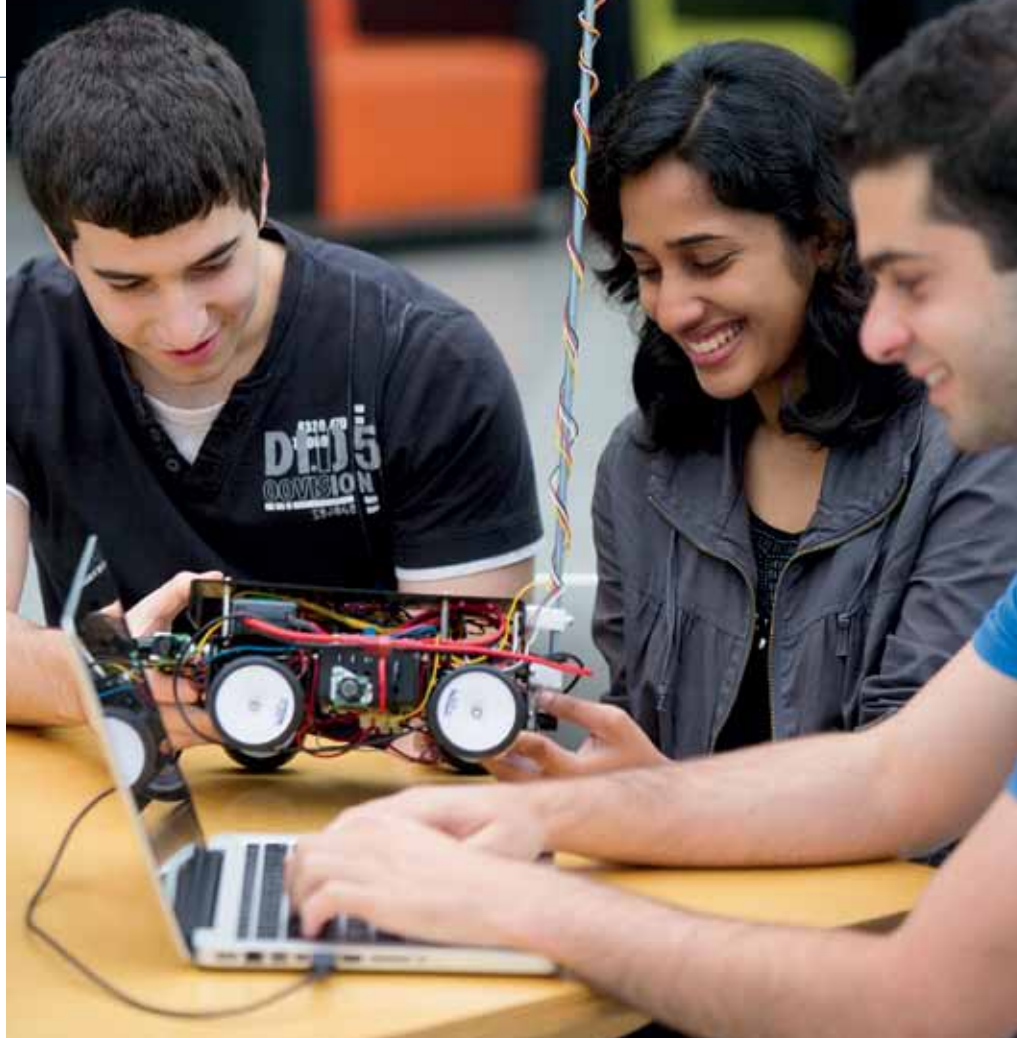
In Latin America government interest in engineering education is focused on the benefits for innovation and competitiveness. GEDC is exploring with the Organization of American States how to provide academic leadership to help universities develop stronger education and research programs, often from experts within Latin America.

A shared theme for all countries is encouraging greater diversity in the engineering workforce.

In many countries, but not all, this includes attracting more women to the profession. In many countries, Australia included, it also means encouraging more indigenous people to take up engineering careers. Many companies are keen on diversity because they believe it improves the performance of their business.

Airbus is a good example of a company that works hard to diversify its workforce. Last year it joined forces with GEDC to launch the Global Diversity Award, recognising academic staff who have improved the diversity of the student body and will therefore, in turn, improve the diversity of the engineering workforce.

Last year's inaugural award was bestowed on Ana Lazarin of Wichita State University, whose own story as a first-generation Hispanic graduate is itself inspirational. The 2014 competition has just been announced and it will continue to raise the profile of diversity in the engineering workforce.



Students at the University of Adelaide.

PHOTO: UNIVERSITY OF ADELAIDE

The GEDC is a forum of like-minded people who care about the international nature of engineering education and who see the opportunities for sharing ideas and good practice, as well as collaborating directly between institutions.

The Australian Council of Engineering Deans is a chapter member and many of our deans are also individual members and playing an active role, very much in the tradition that our country plays on the world stage.

Australia already has a very strong reputation in engineering education (supported by the Australasian Association for Engineering Education) and accreditation (through Engineers Australia), so it is a natural extension for us to be active in the Global Engineering Deans Council.

Not only do we provide some help to other countries, but we gain far more in return to enrich our own engineering education and prepare even better graduates for our future.

PROFESSOR JOHN BEYNON FTSE is Executive Dean of the University of Adelaide's Faculty of Engineering, Computer and Mathematical Sciences, following seven years as Dean at Swinburne University of Technology. Manx by birth, he spent much of his career at Sheffield University, where he held professorial positions in metallurgy and mechanical engineering. He has been President of the Australian Council of Engineering Deans and is now Chair of the Global Engineering Deans Council. He was elected Fellow of the Royal Academy of Engineering in 2007, and holds Fellowships of Engineers Australia, the UK-based Institute of Materials, Minerals and Mining and ATSE.

LETTERS TO THE EDITOR

ATSE Focus welcomes letters from readers in response to published article or on technological science and related topics.

PLEASE KEEP LETTERS BRIEF. LONGER LETTERS MAY BE RUN AS CONTRIBUTED ARTICLES.

Please address to editor@atse.org.au



By Judy Raper
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Future researchers need not be our mirror image

We need to develop 't-shaped' engineers and ensure they both deepen and broaden their skills when they proceed to research degrees.

The way of life and standard of living in the 21st century is driven by innovations in engineering and technology. Educating engineers and technologists to enable this innovation to continue apace is of prime importance.

As a community of professionals, we have been talking about the shortcomings in engineering education for over 20 years.

We have worked to contextualise technical competencies of our graduates to overcome these shortcomings by introducing experiential learning, and programs to develop generic or 'soft' skills. I prefer to call them 'higher order' skills.

We have come a long way in improving our undergraduate programs to help develop 't-shaped' graduates, who have deep disciplinary knowledge with enough breadth to work with graduates from other disciplines, and who can communicate – and work in and lead teams.

Throughout this period though, research training in engineering and technology has

continued along traditional disciplinary lines, following the master and apprentice model in which our postgraduate research students are trained to be just like us.

Society today faces many global challenges, including the big four: the provision of food, clean water, health care and energy. It is in these areas and others that engineering and technology can make a significant and lasting set of contributions that will help to solve these problems and improve the quality of life for the peoples and the nations of the world.

To achieve these solutions, new knowledge, processes and services need to be created and, in their creation, researchers from very varied disciplines must work together.

In research training, Australia lags behind the US and the UK, where Doctoral Training Programs bring together cohorts of research students, each with individual projects, who collaborate in a particular interdisciplinary

area. The IGERT (Integrated Graduate Education and Research Traineeship) program has been run by the National Science Foundation for over 20 years and produces doctoral graduates knowledgeable and skilled in (for example) 'Wind, Energy Science, Engineering and Policy', or 'Integrated Biorefining for the Sustainable Production of Fuels and Chemicals' – among many other areas.

The cohorts for each of these programs include not only engineers and scientists but also students from social sciences and the humanities. While maintaining depth in their own disciplinary projects, students in the cohort develop an understanding and appreciation of the other disciplines through the associated coursework and particularly through collaboration and networking with their colleagues.

Some of our Cooperative Research Centres have PhD programs with similar graduate outcomes, but these are few and far between and not embedded in the

ENGINEERING A KEY TO PROSPERITY

Engineering is important for a prosperous and sustainable future for Australia. It helps create wealth from ideas and will be essential in solving problems in the future. This was the key message of the Academy's submission to the Australian Workforce and Productivity Agency's Engineering Workforce Study. ATSE noted that attempts to improve predictability of future discipline demand had proven ineffective, especially given Australia's low population and relatively small local market.

Engineering degrees, therefore, needed to be positioned to be valued beyond employment prospects in specific occupations.

ATSE said it had identified three National Challenges for improving the quality and reach of science, technology, engineering and mathematics education at all levels:

- improve STEM tertiary education, research and career training to meet future industry, social and economic needs;
- adopt effective pedagogies and educational practices within STEM education at all levels; and

- support STEM secondary school teachers to improve teaching of STEM and STEM literacy

These National Challenges would be important in meeting Australia's future engineering skill needs, ATSE said in its submission.

It noted that the nature of engineering practice is such that the widespread availability of advanced engineering and technological skills is likely to lag behind demand.

Among professional engineering occupations during the past decade, Australia had seen shortages of experienced systems engineers, software engineers, mining and construction engineers, and power systems engineers.

While deep experience was gained in employment, many companies recruited and valued graduates for their knowledge of and aptitude with new software tools. Otherwise, companies sourced skills by immigration, recruited from each other or partnered with each other on major contracts to retain specialised skills within consortia.

higher education research funding scheme.

The Higher Education Research Council in the UK has embedded Doctoral Training Centres in the way research students are supported. These encompass cohort programs for both fundamental studies and Industrial Doctoral Centres (IDC), jointly funded by industry and government.

Examples of successful IDCs include 'Urban Sustainability and Resilience' at University College London; and 'Innovative and Collaborative Construction Engineering' at Loughborough. The programs are undertaken as partnerships between industry and academia to provide students with experience of rigorous, leading-edge research in a business context.

Research development relies on partnerships between universities, government and industry. It is of note that even though 88 per cent of Australian expenditure in engineering and technology research and development comes from industry, by far the majority of higher degree research graduates work in academia or government.

Industry clearly sees the need for the creation of new knowledge through research in order to develop the products, systems and services that are essential to the continued growth of our economy. It is not clear though, that industries value the human capital developed through research training.

The outcomes of the research, including both the discoveries, products and services, as well as the workforce, should ideally be attractive to all partners. So research training for engineers and technologists needs to be more focused on training graduates who are capable of adding value through innovation, entrepreneurship, global competence and leadership.

Our students and graduates need not only to create innovations but also to convert scientific discoveries into functional, marketable, profitable products and services. They should understand business and commercialisation processes and legal aspects, as well as the social sciences required to get products to market.

Universities and research institutes should offer our students access to courses and training opportunities in these areas to gain the skills that would make our graduates more attractive to all partners in the research



Strong focus in the engineering laboratory.

training collaboration, especially industry.

There are several ways in which we can improve research training in engineering and technology to ensure that our industrial colleagues recognise, appreciate and value the importance of research and the creation of new knowledge. One way to achieve this is to give our students greater access to the courses and cohort programs described above – and to ensure they are deeply immersed in their chosen discipline but also develop an understanding of other disciplines and gain the skills required to fuel the innovation ecosystem.

In the long term, industry appreciation of research can also be achieved through the education of our undergraduate engineers and technologists, who make up the majority of the industrial workforce. All our professional graduates should appreciate the value of research.

To this end it would be beneficial to offer research experiences for undergraduate engineers and technologists. This experiential learning would not be limited to a capstone research project but could involve research electives throughout their undergraduate programs.

Summer or winter schools for research are also a very valuable way to introduce undergraduates to research. These can be conducted in cohorts similar to Doctoral Training Programs, comprising students from several disciplines working together to achieve superior learning outcomes.

Some of these ideas have been discussed

for many years and several universities in Australia have followed some or all of the approaches described. However, many of our graduate engineering and technology research training programs have not changed in decades and fail to capitalise on the inroads made in improving undergraduate engineering courses.

There is a need to change policies and funding, both government and institutional. This is an area where the ATSE community could provide leadership and influence.

What we need is to develop 't-shaped' engineers and ensure they both deepen and broaden their skills when they proceed to research degrees.

It is time we recognised that the future research workforce needs not be a mirror image of ourselves.

PROFESSOR JUDY RAPER FTSE is Deputy Vice-Chancellor (Research) at the University of Wollongong and was previously the Division Director of Chemical Bioengineering, Environmental and Transport System at The National Science Foundation (NSF) in the US. Prior to this secondment, she was Department Chair, Chemical and Biological Engineering at the Missouri University of Science and Technology (2006) and Dean of Engineering at University of Sydney (1997 to 2003). Professor Raper received the Sheddon Pacific Award for most outstanding young chemical engineer in Australia in 1992 and Professional Engineer of the Year in 1998. In 2012 Professor Raper was named one of Australia's 100 most influential women, and in 2013 one of Australia's Top 100 Engineers.



By Ian Cameron
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Challenges, opportunities and innovation in the engineering education landscape

The past 20 years in higher education has been one of the most rapidly changing periods in the 200 years of formal engineering and technology education.

How do we create effective and motivating learning environments that help meet higher education needs both now and into the 2020s?

This challenge comes against the backdrop of large rises in engineering student numbers, employer demands for increased levels of critical thinking skills, improved graduate understanding of theory and practice, and adaptability for global challenges and roles.

These challenges are not new. However, given the existing national and international context they are now all the more crucial to higher education and the engineering and technology sector.

For those in the higher education sector, these challenges demand understanding of student and academic demographics, awareness and application of modern learning sciences and a commitment to innovative practices that challenge students' thinking while drawing industry more closely into higher education.

Only through these realisations can we truly create learning environments that produce graduates with capabilities to function in an increasingly complex world. It can't simply be 'business as usual'!

The past 20 years in higher education has been one of the most rapidly changing periods in the 200 years of formal engineering and technology education.

It has been characterised by the rise of internet and communications technologies, an expanding globalisation of engineering, upwards of a five-fold increase in student numbers and a rapid decline in the proportion of academics with professional engineering experience outside higher education. Change is inevitable and much is happening, but will it result in systemic change?

As with professional engineering, the learning environments expressed

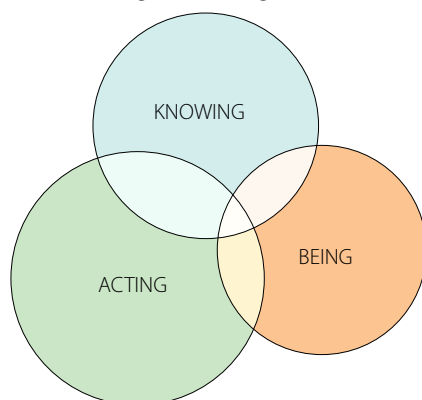
in curricula need a strong systems perspective in both design and operation. It's simply not good enough to just stagnate in a single adopted position. Aspects such as curriculum design, graduate student capability profiles and learning and teaching processes become vitally important issues to create learning environments that drive engineering and technology education into the next decade.

This is not to suggest that prescriptive processes are essential goals in any educational design. Innovation, adaptation and resilience to changing demands are essential.

Ultimately, the education process comes down to some very basic ideas. Ron Barnett from the Institute of Education at the University of London expressed it elegantly as: Knowing, Acting and Being.

The schema shown in Figure 1 should generate considerations around knowledge domains, how theoretical knowledge can be taken and acted upon in a range of well-defined to complex situations in order to facilitate the development of professional and personal attributes of graduate engineers or technologists.

Figure 1 This schema not only shows the relative importance of key concepts in a particular curriculum but also the intended degree of integration.



Of course, those curricular design and operational considerations are complex within themselves. They require insightful planning, informed design and excellent execution to drive curricular success.

They take seriously the wise and abiding words of John Dewey (1916): "We never educate directly, but indirectly by means of the environment. Whether we permit chance environments to do the work, or whether we design environments for the purpose makes a great difference."

Creating physical and virtual spaces or places and the activities that might occur in those spaces involves innovation and perspiration! Much energy needs to be expended to create truly impactful learning environments that deal with knowledge, exercise it in challenging ways and change students' understanding, inquisitiveness, perceptions, attitudes and skills.

In this context it's worth recognising a continuum from teacher-centred learning through student-centred learning and into self-directed learning. These might be expressed in ideas captured by concepts in pedagogy, andragogy and heutagogy. We need to build learning across this continuum, and this is a shared responsibility of universities, professional bodies and employers. If this learning environment remains solely within the confines of the institution then we have severely limited our possibilities.

Surveys of engineering and technology students have consistently established their overriding interest in problem solving, design and creating activities, along with application of practical, hands-on skills in a range of contexts.

Much has happened, or has been resurrected in this space. Design projects can be created for very large first-year cohorts, where team-based designs tackle practical problems that integrate complex

contexts with nascent system thinking, modelling, construction and testing. Often the challenge in such student-centred or self-directed learning environments is the lack of consistent progression of such activities through the whole curriculum. That's an ongoing challenge in the design of learning pathways.

In the teacher-centred space, where direct instruction is often used to deal with knowledge or discipline content, there is a growing movement towards the 'flipped' classroom concept, where content is addressed by the student and face-to-face class time is devoted to the application of that content to skill development via projects, case studies or exercises.

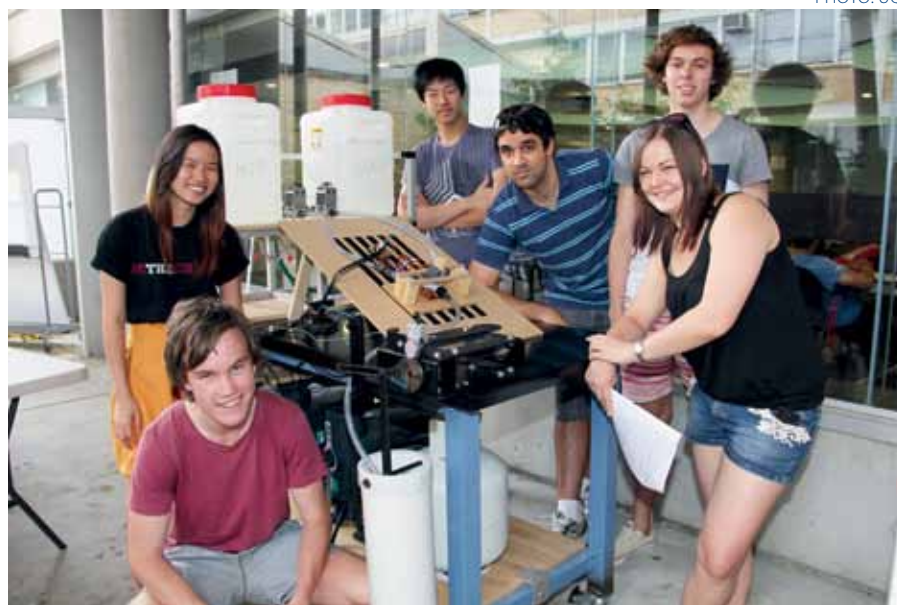
This of course is hardly a new idea, having origins in the Classical Greek period! However, due to the plethora of excellent knowledge sources now accessible through the internet, it employs a student-centred approach to effective learning. Why not acquire and understand content via some of the world's top experts, courtesy of YouTube, and then put it to work in practice sessions?

If you adopt project-based learning paradigms, as is increasingly the case in engineering and technology education, then you can tap into self-directed learning where many new areas of knowledge, skills and attitudes are driven through the challenge of the project. Much can and has been done around project-centred curricula, with many exemplars available that testify to its efficacy.

The idea of moving from physical, real spaces into the virtual is now readily achievable. The ability to take learners into virtual spaces/places can have powerful learning and attitudinal outcomes that can enhance decision-making within complex environments. It also allows educators to take students into locations of enhanced risk without the subsequent consequences – from open-cut or underground mining operations to the heart of major hazard facilities, or the visualisation of nano-scale phenomena to mega-scale systems.

The possibilities are extensive, but research is still needed to understand the optimum way to use these systems for desired learning outcomes.

The rise in hybrid systems that combine the virtual with the real – so-called 'augmented reality' systems – can



First year engineering students work at water mixing.

be used to great effect where knowledge and processes can be overlaid on actual physical realities. This presents opportunities to improve learning, deepen understanding and generate enhanced decision-making. Many of these virtual systems can now be developed by students using mobile technologies, then shared via cloud services or online repositories.

It would be remiss not to mention the rise of the Massive Open Online Course (MOOC) phenomenon that has arisen over the past six to seven years. Providers such as Udacity, EdX, Coursera and Iversity have attracted the attention of Australian universities, with several institutions directly involved in these consortia as partners. They have been an outgrowth from the Open Educational Resources (OER) movement that dates back several decades.

MOOCs create interesting opportunities for educational institutions to internationalise their course offerings. MOOCs also create interesting challenges in disruptive curriculum design as degree programs open up the possibility of assembling coherent learning pathways via 'traditional' campus-based courses, mixed with certificated MOOCs.

What is clear is that fee-for-access MOOCs generally carry with them the necessity for very large investments in high quality production and delivery. Much is yet to be understood about the best business models for such educational innovations, so it

is a matter of 'watch this space'.

This article presents a brief snapshot of the current learning landscape in higher education, and notes some of the challenges and opportunities and some ongoing innovative learning practices and platforms.

The fundamentals of Knowing, Acting and Being are at the heart of this endeavour.

None of this becomes a reality without effective partnerships. Those partnerships must exist within and across academe. But, more importantly, in a world of changing student and academic demography it is essential that industry and the professions play an increasing support role to ensure that the educational designs, processes and innovations truly provide graduates who can confidently address national and global challenges.

PROFESSOR IAN CAMERON FTSE is Professor in Chemical Engineering at The University of Queensland (UQ) a director and principal consultant at Daesim Technologies in Brisbane. He obtained his PhD in Process Systems Engineering from Imperial College London. He spent 15 years with major Australian and international organisations in diverse industry sectors such as sugar, building materials and industrial chemicals, with roles in process and control system design, plant commissioning, production management and environmental protection. He has spent the past 25 years in research, consulting, teaching and learning innovation at UQ. His numerous awards include the 2003 Australian Prime Minister's Award for University Teacher of the Year.

PHOTO: UQ

ATSE has an array of education programs

The Academy stresses the importance of Science, Technology, Engineering and Mathematics (STEM) education – and is working across the country to lift the nation's inclination to undervalue STEM subjects.

STELR

STELR (Science and Technology Education Leveraging Relevance) is ATSE's flagship education initiative, which directly aims to address the problem of low participation rates in Australia in science and mathematics subjects at the upper secondary school level.

The STELR Project is in more 400 schools from all states and territories, with more than 35,000 students and 1000 teachers involved each year. So far STELR has benefited more than 150,000 students.

The main theme is renewable energy. This taps into the high level of concern students have about global warming and climate change.

STELR also aims to:

- improve the level of science literacy and understanding in the community;
- raise awareness of opportunities in technology-related careers;
- prepare students to engage with science ideas and be knowledgeable about the way science and scientists work;
- increase the number of students choosing science and engineering careers to address the shortage of science and engineering graduates; and
- improve the quality of science classroom teaching practice.

At the end of 2013, 45 coordinators from STELR schools completed a survey to evaluate how STELR is achieving its aims.

- More than 50 per cent of respondents reported an increase in students studying science at year 11. One school reported a 100 per cent increase in students studying physics at year 11.
- More than 90 per cent reported that boys and girls were either 'more engaged' or 'much more engaged' with STELR compared with regular science topics.

- Teachers teaching 'out of field' reported feeling more confident when teaching the STELR modules.
- The survey showed students were more aware of what was involved in engineering and technological careers and the study pathways necessary to gain access to these careers.
- The survey reported the science literacy of students had increased in more than 80 per cent of schools.

iSTELR is a web-based version of STELR, which provides an enhanced learning experience for the students, incorporating multimedia and interactive elements. For teachers, it provides a simplified workflow – student work is instantly accessible and teachers can provide feedback as required. New web-based modules on Sustainable Housing and Space Science will be launched in July.

Sponsorship is a key as STELR is totally funded through sponsorship and donations. STELR's main sponsors include Orica Pty Ltd, the Australian Power Institute, CIGRE, Cochlear, the University of New England, the University of Wollongong and Deakin University. Sponsorship funds salaries, curriculum development and subsidies for many schools to buy STELR's Australian designed and manufactured equipment.

International engagement is strong – STELR has been enthusiastically received by the New Zealand Department of Education. The Secondary Student Achievement Professional Learning and Development team has been trained and will promote STELR to science teachers at their workshops. STELR curriculum materials have been translated into Indonesian. STELR workshops have been delivered as a part of UNESCO-sponsored training programs for Asia-Pacific and emerging nations. STELR's sponsor Orica is extending the STELR program to targeted schools in the Asia-Pacific region.



ATSE Vice President Professor Mike Miller (right) presents the 2012 Teacher Award to Dr Paula Mills of Prince Alfred College, Adelaide, with Mr Nicholas de Dear, Head of the PAC Senior School.

Solar car kits have been provided free to more than 50 schools as a part of the Australian Power Institute solar car challenge, which also involves hosting a visit from an undergraduate engineer who will talk to the students about careers.

Wonder of Science

The ATSE Queensland Division's 'Wonder of Science' program is mobilising young enthusiastic scientists and utilising university facilities and resources to demonstrate to Queensland students that science is fun, exciting and rewarding. There is a particular focus on rural, remote and indigenous students, who would not ordinarily receive the same level of support as those in the south-east of the state.

The program is aimed at students in Years 6 to 9 who are responsive to challenging, real-life tasks that spark their natural curiosity. They are challenged and inspired through completion of a project, with the opportunity to participate in a culminating conference where they engage in the process of scientific investigation and experience scientific critique through peer review. A key benefit of the Wonder of Science program is that the student research project is designed to be embedded in the teaching and learning program and is aligned to the Australian Curriculum.

The program is supported by enthusiastic Young Science Ambassadors (university PhD students) and industry and university partnerships. Implementation of the program in rural and regional Queensland schools in 2012-13 has shown that the program is really making a difference for students. The regional conferences held in Cairns, Townsville, Mackay and Rockhampton in 2013 showed that participating students were highly motivated and demonstrated high levels of accomplishment with their projects and conference presentations.

SA Challenge

The Science and Engineering Challenge, an award-winning initiative of The University of Newcastle, was so successful in enthusing Years 9 and 10 girls and boys in STEM that it quickly spread its influence nationally. From modest beginnings in Adelaide in 2003, The SA Challenge, with support from a large number of sponsors including



Working on a Wonder of Science project.

the ATSE SA Division, has now expanded to encompass more than 80 metropolitan and country schools. Teams of 30 students compete in stimulating practical exercises (for example, building and testing a bridge, a hovercraft, an 'eco' house, a water pipe network) and the eight top-scoring schools compete in the SA Super Challenge for a place in the National Grand Challenge.

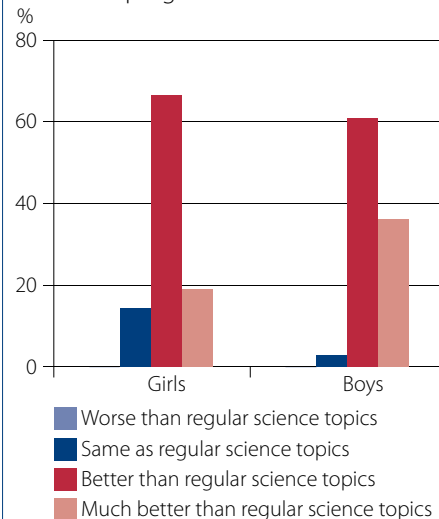
STEM Teacher Award

In 2006, ATSE SA Division Committee established an award for an outstanding teacher in STEM subjects to promote its strong support for STEM education. Presentations to the winning teacher and a cheque and perpetual trophy to the school's principal for STEM-related activities in the school are made annually. The Award is in its ninth year.

Eminent Speaker Series

The annual WA Eminent Speaker event is conducted in collaboration with Scitech WA, Curtin University, Edith Cowan University (ECU) and The University of Western Australia (UWA). The WA Division selects inspiring speakers and subjects to connect with both young people and the general public. The core program consists of three talks in Perth

Figure 1 Student engagement with the STELR program is:



by a single presenter and, from 2014, additional lectures in regional areas.


Two of the three Perth-based presentations are organised by Curtin and ECU, the presentations taking place at their campuses for Year 9 and 10 students. The third presentation at UWA addresses the public through their extensive contact list, and takes place in the auditorium of the University Club. Audience numbers for these presentations typically range from 100 to 200.

ATSE IN ACTION

Would you drink recycled water?

The Academy recently convened a public presentation on the scope for direct potable water recycling in Adelaide. This report is from Dr John Radcliffe AM FTSE, Secretary of the SA Division of ATSE. He chairs the AWRCoE Research Advisory Committee, and was a commissioner of the National Water Commission from 2005–08.

PHOTO: ISTOCKPHOTO



High quality effluent from modern wastewater treatment plants provides an excellent basis for the Advanced Water Treatment processes to produce water for direct potable reuse.

As part of its work the Australian Water Recycling Centre of Excellence (AWRCoE) commissioned an independent report from ATSE on the costs and benefits of supplying recycled water directly to the drinking water system.

This report – *Drinking Water Through Recycling* – formed the basis of the ATSE lecture, titled ‘Would You Drink Recycled Water?’, which was held in association with the Royal Institution Australia, in Adelaide in May.

Dr Stuart Khan from the University of NSW and principal author of the ATSE Report, drew the audience’s attention to water currently being recycled and the extent of *unplanned* indirect potable reuse (IPR) in many parts of Australia and contrasted this with several *planned* IPR projects in the US, including in New Mexico and California, and in South Africa.

He explained the legislation requiring

the Californian Department of Public Health to have uniform criteria for IPR through surface water augmentation and groundwater recharge and to report on the feasibility of developing uniform criteria for direct potable reuse (DPR) by 2016.

His report concluded that DPR is technically feasible, can safely supply drinking water into the water distribution system but that advanced water treatment plants are complex and need to be operated effectively with appropriate oversight. DPR should be considered on its merits among the range of available water supply options for Australian cities and towns.

Dr David Cunliffe, principal water quality adviser, Public Health, South Australian Department of Health, commented that the public underestimated the effort made to ensure that water supplies are safe.

DPR had risks that must be managed. Despite National Water Quality Management Strategy guidelines for using recycled water to augment drinking water, 24-hour monitoring was essential, particularly to overcome any risks of human error.

Production timing issues were important and engineered storages may be required to replace those of indirect river or reservoir storages to be able to catch and deal with any errors.

It was noted that, although the public was highly conscious of chemical contamination, this represented far less of a health risk than biological contamination.

Items that kept the regulators awake at night included plant performance variability, unidentified holes in the reverse osmosis membranes, UV lamp failures and alarm failures.

Missing an operator error could lead to disaster and Dr Cunliffe emphasised there should be no limits on safety.

The following Q&A session covered a variety of topics, but there was implicit acceptance of the potential to develop confidence in DPR where the community sees that there is a well-developed water resource and economic case

supported by sound science and respected regulatory systems. The participants agreed that the public expected government to have primary control in terms of regulatory standards and safety.

RECOMMENDATIONS FROM DRINKING WATER THROUGH RECYCLING

While optimum solutions will continue to be case-specific, ATSE is convinced of the technical feasibility and safety of drinking water supply through DPR when properly managed. ATSE considers there can be considerable environmental, economic and community benefits of supplying highly treated recycled water direct to drinking water distribution systems in suitable circumstances.

ATSE concludes that DPR should be considered on its merits – taking all factors into account – among the range of available water supply options for Australian towns and cities.

ATSE is concerned that DPR has been pre-emptively excluded from consideration in some jurisdictions in Australia in the past, and these decisions should be reviewed.

To stimulate adoption of DPR where appropriate, ATSE recommends:

- regulation of drinking water quality should be health-based;
- harmonise guidelines to improve management and regulation of DPR projects;
- implement external auditing of water quality management;
- enhance capabilities and powers of regulators;
- improve water treatment process reliability, monitoring and validation; and
- establish DPR reference sites around Australia and develop community engagement programs about water reuse.



The Australian Synchrotron: a world-class shared research facility.

This article, by Academy President Dr Alan Finkel AM FTSE and Vice Presidents Professors Peter Gray and Tanya Monro, was first published by *The Australian* in April.

Large-scale research infrastructure the building blocks of the future

We've all been shocked by the disintegration of our car industry. The next car wreck could be higher education and our potential to develop the manufacturing industries of the future.

Our higher and tertiary education sector is performing well, with six universities in the world's top 100. With the liveability of our cities, this makes Australia a popular destination for international students. International education is now our fourth-largest export after iron ore, coal and gold, and our biggest services export, ahead of tourism and banking.

But will it last?

When foreign students consider their options they look at the rankings of the universities. The major international university rankings are highly weighted towards research output.

Australia has done well in recent years because of our substantial national investment in research capability. Indeed, many foreign-born researchers who took up positions in Australian universities in the past 10 years will say they came because they could undertake research here that they could not do where they came from.

Scientific and technological advances are made possible by new generations of instruments, from laboratory equipment to large machines costing tens or even hundreds of millions of dollars. The latter are installed at central facilities. Priced beyond the capability of individual universities or companies to build, they have to be built by government for use by researchers throughout Australia.

The Australian Synchrotron, the Australian National Fabrication Facility and the OPAL research reactor are shared facilities that have made advanced research possible in Australia.

Some examples:

- researchers using the Australian Synchrotron won the 2013 Eureka Prize for their discovery of a new type of immune cell in the gut, opening up the possibility of new drugs to target invasive bacteria;
- based on prototypes developed at the Australian Institute for Bioengineering and Nanotechnology, the 'Nanopatch' is a silicon-chip replacement for conventional syringes for the delivery of vaccines painlessly, inexpensively and more effectively; and
- Lithicon's nanometre-scale 3D imaging of mineral core samples for the resources sector was developed using the focused ion beam machining system run by the Australian National Fabrication Facility.

The Federal Government's NCRIS scheme is an excellent example of government investment in research infrastructure that has supported research successes in industry and academia. However, NCRIS will expire by the middle of next year, leaving Australia with a worryingly reduced ability to operate our existing facilities and retain the skilled operators.

Going back a decade or so, visionary State and Federal political leaders committed funds for the creation of national research infrastructure year after year, showing a deep understanding of the long-term nature of the investment. The benefits have been tangible and they continue to this day.

But in the fast moving world of science and technology new requirements for large-scale research infrastructure continue to emerge – and they take years to plan and build.

About six years ago the Federal Government's forward planning abruptly ceased and the last of the set-aside funds were eventually spent. Since then, no funds or plans have emerged to build the major research infrastructure of the future.

There are two reasons we should care.

First, the long-term viability of our higher education industry depends on our ongoing ability to undertake world-class research.

Second, the continued decline in traditional manufacturing in Australia means that we have to be smart in developing the advanced manufacturing industries of the future.

Research infrastructure and skilled staff are critical in enabling industry to access emerging technologies – from big-data analysis too complex for today's supercomputers to large-scale additive manufacturing techniques developed in shared automation research centres yet to be built.

The UK Government is ahead of us. As highlighted by Minister David Willetts during his recent visit to Australia, the UK Government announced, after a Parliamentary Committee review into research infrastructure, that it would invest an inflation-adjusted £1.1 billion a year for six years.

Our education industry is vibrant. We need to keep it so.

For manufacturing to thrive, new technologies and approaches will be needed, driven in many cases by research conducted collaboratively with research institutes and universities. But their capacity is being eroded by a lack of investment into research infrastructure.

This in turn threatens the reputation on which our education export industry depends. It's a double whammy.

To ensure the competitiveness of our education export industry and our future manufacturing industries the Federal Government should consult with the public and private research sector to develop a long-term investment plan for the large-scale research infrastructure that will support our educational institutions and our future industries.

ATSE IN ACTION

ATSE backs its Strategy Plan on three fronts

ATSE has strongly backed its Strategy Plan recently with publication of three major papers on key areas of the economy where technology has a key role to play.

This is in line with the ATSE 2012-2017 Strategy Plan, which sets out the priorities and approaches the Academy will take to enhance Australia's prosperity through technological innovation.

In the past two months the Academy has published and distributed Position Statements on Agriculture and Energy and an Action Statement on Innovation and Productivity.

offsetting and reducing them

It sees new opportunities for Australian agrifood industries in production, processing and marketing to meet growing international demand for safe, high-quality food and fibre products, especially from an increasingly affluent middle class in Asia.

It says to create enduring advantage in these competitive markets, Australian agriculture must boost its output, quality, value and sustainability – recognising that water, infrastructure, transport systems and global market access are critical,

ATSE says priority areas where technology, science and engineering-driven innovation can play key roles include biotechnology, information technology services, water, environmental impacts and natural resource management, biosecurity, enhanced product specifications and certification, and waste reduction.

The **Energy Position Statement** – *A Sustainable Energy Future for Australia* – says to support its sustainable development and future prosperity, Australia must move to low-emissions energy systems that are affordable, secure and reliable.

It notes that:

- energy is essential to Australia's economy;
- its availability, affordability and efficient use are key drivers of business productivity and social well-being; and
- Australia is a net energy-exporting nation, with considerable national wealth derived from our exports of energy resources, including coal, uranium and liquefied natural gas.

Australia has for many years enjoyed comparative advantage through the wide availability of large, low-cost energy sources, particularly for electricity generation, it says.

"With national and international efforts and agreements to reduce emissions, natural gas moving towards international parity price and coal recovery cost following at a lesser pace to price levels that are not affordable within the present Australian context, this advantage is quickly disappearing."

Developing and implementing policies that will deliver a transition to a low-emissions energy future while maintaining adequate,



The **Agriculture Position Statement** – *Enabling Growth in Agriculture* – was launched in April and calls for the integrated pursuit of increased productivity and the enhancement of ecosystems to secure the future growth of Australia's agricultural sector.

It notes the pressures threatening global food security and agricultural production and calls for concerted action by industry and governments across agricultural and food value chains to increase the use of technology, science and engineering in



There is increasing pressure on the availability of natural resources for agricultural production, due to drought, changing land and water use patterns, competition from other industries, increased input costs and environmental degradation. To maintain and accelerate agricultural production growth, Australia must utilise its natural resources more efficiently.

Success will require partnerships and collaboration between industry, governments and financial systems to invest in future international competitiveness.



RET is working, says ATSE

ATSE says in a submission to the Renewable Energy Target Review that the RET is meeting the objectives of the *Renewable Energy (Electricity) Act 2000* (REE Act) and should be continued in its current capacity.

It notes, however that there is scope to expand the target if low-emissions sources of generation were allowed.

ATSE said the RET had:

- successfully encouraged additional generation of electricity from renewable sources, with more than two million small-scale renewable energy systems being installed under the RET – and generation from renewable sources increasing since 2001, with wind energy experiencing large growth; and

- contributed to the reduction of emissions of greenhouse gases in the electricity sector.

The objectives of the REE Act remained appropriate in light of falling electricity demand and the Government's target and policies for reducing greenhouse gas emissions. The transition to a low-emissions energy sector would not be possible without affordable, reliable, low-emission technology solutions.

The fall in electricity demand was, in

ATSE IN ACTION

reliable and competitive energy supply is Australia's – and the world's – key challenge.

Policies, programs and regulatory mechanisms are essential to support the development of new technologies and their integration into existing supply chains to foster the transition to low-emission energy technologies.

Market forces and enabling regulatory regimes must drive Australia's energy transition, it says.

The **Innovation and Productivity Action Statement** – *Translating Research into Economic Benefits for Australia* – says Australia has excellent capabilities in basic research but without effective commercialisation the full economic benefit cannot be realised.

It suggests that better translation of Australia's publicly funded research into economic outcomes for Australia can be achieved by:

- improved linkages between publicly funded research organisations and industry – technology intermediary organisations have an important role to play in facilitating these linkages; and
- targeted and sustained incentives for translational research and business development and innovation.

It says connecting researchers and industry is imperative to build strong, innovative industries – an innovative, productive, profitable industry culture requires the contribution of intellectual property from research institutes and businesses.

"In many OECD countries it has been demonstrated that industry assistance programs are needed and those whose value is proven must have significant scale and long-term stability to provide investment certainty.

part, a consequence of using renewable technologies as sources of electricity generation (in particular small-scale solar panel installations and improved competitiveness of large-scale wind generation), ATSE said, noting it had been estimated that, during the period 2001–12, the RET had reduced Australia's emissions by 22.5 million tonnes of carbon dioxide equivalent.

The RET has been a key factor in reducing



"Indeed, even overseas governments that are doing well in technological innovation have recognised the need to intervene consistently. Government assistance for firms in Australia is low by OECD standards."

The Action Statement says collaboration provides affordable and rapid access to skills, people, equipment, facilities and ideas and contributes to improved productivity. Collaboration between businesses and publicly funded research organisations must be improved if Australia is to realise the economic benefits from its world-class research.

Australia has fundamental systemic barriers, including financial barriers, information asymmetry, differing timescales, absorptive capacity and cultural differences that can cause a mismatch of goals and different risk/reward perceptions.

A lack of incentives, including via targeted government assistance programs, for research translation to technological innovation and commercialisation remains a fundamental problem in Australia.

All three Statements are on the ATSE website at Publications/Policy and Technical

emissions and electricity demand, although it has not been the only determinant.

A decline in electricity demand was reflective of the contracting industrial market, with closures of energy-intensive industries, as well as delays in investment in new industries.

While energy costs may be a small component of this, the major impacts had arisen from labour costs, costs of construction and the retirement of ageing or suboptimal facilities.

ATSE CLUNIES ROSS AWARDS A GREAT SUCCESS IN PERTH



The Academy took its ATSE Clunies Ross Awards dinner and Extreme Science Experience to Perth for the first time in May – and the combined events were again an outstanding success.

The awardees are recognised as Australia's pre-eminent innovative scientists and technologists for persisting with their ideas, often against the odds, to the point that their innovations have provided broad economic, social or environmental benefits. The 2014 ATSE Clunies Ross Award winners were:

Dr John Nutt AM FTSE (Lifetime Achievement Award) for his ongoing contribution to the engineering profession and commitment to the advancement of the industry over the past 50 years.

Professor Kevin Galvin FTSE from the University of Newcastle for his work in mineral processing and the development of innovative, cost-saving and effective minerals industry technology.

Dr Ezio Rizzardo FRS FAA FTSE, Dr Graeme Moad FAA and Dr San Thang FTSE for their work in have developing better ways of making polymers and plastics.

Mr Ravi Ravitharan, Mr Peter Mutton and Mr Graham Tew for their significant technical innovations in railway engineering.

Winthrop Professors Eugene Ivanov and Michael Tobar FAA FTSE for their invention of the world's lowest-noise oscillators, with multiple applications in fundamental research, high-tech communications and defence.

The ATSE Clunies Ross Awards were presented at a gala dinner at the Perth Convention Centre attended by more than 370 eminent entrepreneurs, decision-makers, government officials, researchers, academics and business leaders.

It was opened by the Hon Colin Barnett MLA, Premier of Western Australia, followed by a keynote address from Professor Ian Chubb AC, Chief Scientist of Australia.

The following day the winners joined nearly 300 students and teachers from across Western Australia in the Extreme Science Experience with hands-on activities to excite students about science and technology.

Full coverage and pictures of both events in the August edition of ATSE Focus.

ATSE IN ACTION

Change can make us “Asia’s delicatessen”

The Australian food sector needs to change if it wishes to achieve continuing growth and take advantage of domestic and international opportunities.

A dramatic boost in competitiveness is needed – as well as fast and agile innovation – accompanied by initiatives to diminish over-regulation and cost imposts in infrastructure, energy and labour.

It is not realistic to expect Australia to be the food bowl of Asia, but it can become the “delicatessen of Asia”, by producing high-value products that trade on our natural advantages and meet the needs of consumers – but at a competitive price.

These were key points made at a one-day food issues seminar in Sydney in May – *Innovating for our Food Future: Mining Boom to Dining Boom?* – which was held by the ATSE NSW Division in association with CSIRO and the Australian Institute of Food Science and Technology (AIFST).

Mr Gary Dawson, Chief Executive, Australian Food and Grocery Council, said that, over the past seven years, Australia had lost almost half of its key import markets in Asia and its global competitiveness ranking had reduced.

If Australia was serious about Asian markets it would take urgent action to reduce debt and regulation. He said Australia had a natural comparative advantage in



On the panel (from left): Gary Dawson; Terry O'Brien; David Thomason, Director, Seafood CRC and Director, Fisheries R&D Corporation; and Chris Downs, Deputy Chief, CSIRO Division of Animal, Food and Health Sciences.

agribusiness, but this did not translate directly into food exports.

With reference to China, he noted:

- Australia's share of the market has decreased, while other countries' shares have increased;
- high-end, gourmet food halls and supermarkets had emerged – where import status and country of origin were

advantages and signifiers of quality, with a price premium in some categories;

- strong interest in Australia as a source of high-quality processed food and a growth of e-commerce for imported food; and
- growing middle class and increasing urbanisation is a growing trend – with rising income and shifting diets – was increasing

ATSE issues high on the SmP agenda

ATSE was again a sponsor of Science Meets Parliament (SmP), run by Science and Technology Australia, at the National Gallery and at Parliament House, Canberra, in March. The conference brought together more than 200 scientists and engineers to discuss science policy issues and to meet with Parliamentarians.

Speakers included leading academics, journalists, government officials and Parliamentarians, including the Hon Ian MacFarlane MP, Minister for Industry, and the Hon Bill Shorten MP, Leader of the Opposition. The conference had an interactive format and

included presentations, small focus meeting and seminars.

ATSE's representative at the conference, Harriet Harden-Davies, reported that ATSE's strategic priority focus areas were strongly reflected in the conference discussions – emphasising the importance of science, technology and innovation for Australia's prosperity.

The first day featured a discussion with leading journalists and science communicators of the opportunities and challenges of achieving effective science communication. An interactive session showed delegates how

to use social media effectively to better communicate a message to a wider audience.

There was broad agreement that investment in science, technology and engineering is crucial to underpin innovation. Many speakers highlighted the importance of investing in cutting-edge technology to support economic growth.

One speaker took delegates on 'a journey through the policy factory', which highlighted the importance of understanding the policy-making process in order to enable scientists to identify how to engage.

The second day of the conference gave

ATSE IN ACTION

demand for protein (meat and dairy) and discretionary foods (like chocolates), but other countries had capitalised on these trends faster than Australia.

He said Australia was unlikely ever to be the food bowl of Asia but, more realistically, could be the delicatessen for Asia with high-quality, premium products and a solid safety record.

Mr Dawson said a viable domestic food-processing industry was critical for good industry growth in domestic and international markets to sustain a \$111 billion sector with more than 300,000 jobs and \$24 billion in exports.

He said it was not enough to be clean and green – Australia's national food brand must encompass quality, provenance and safety – and the nation needed a step change in food sector investment if it was serious about a dining boom.

Infrastructure was impacting on competitiveness, as were regulations and labour and energy costs.

Australia had innovators, designers and marketers but to capitalise on its food potential it needed to drive change by balancing profits, increasing supplier innovation, enhancing cooperation across the value chain and finding new drivers of economic growth.

Mr Terry O'Brien, Chief Executive, Simplot Australia, and Chairman, Australian Food and Grocery Council, said Australia was less competitive globally and less profitable because:

- the Australian dollar was reducing global competitiveness;
- Australian manufacturing and energy costs were rising rapidly;
- very flat turnover figures for manufacturers over the past few years;
- Australia had a small grocery market, felt through all aspects of the value chain, with the added complexity of our geographic size; and
- the cost of running a food business in Australia predicated a comparatively high Australian spend per head on food.

He noted that Australian incomes had risen quickly, but the percentage spend on groceries remained the same proportion of discretionary income, while the quality, safety and choice of food has dramatically increased over the past 10 years.

He said Australia had a great future in food but change was needed to recognise:

- a collaborative effort across the whole chain was required;
- not everyone would survive because of the need to look and be different;
- productivity and agility would be key components; and

- precedent was the enemy – we should not merely do what we had done before.

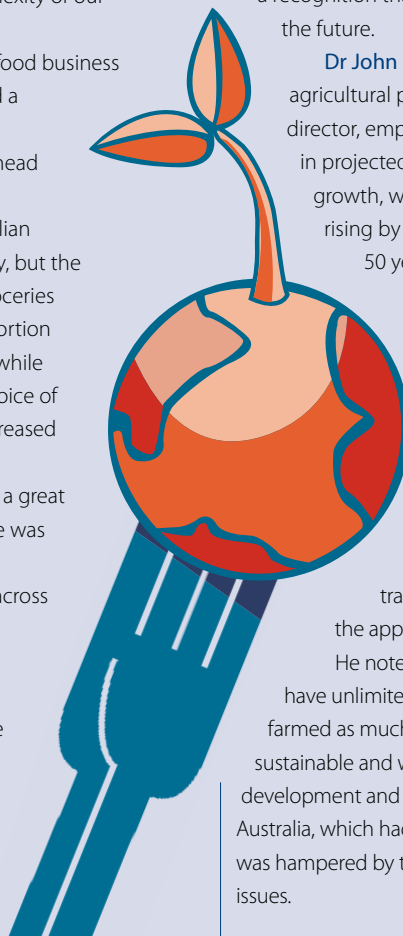
Professor Mary O'Kane FTSE, NSW Chief Scientist and Engineer, endorsed a whole-of-food-chain approach, from primary industries through to manufacturing, with the emphasis on R&D and innovation, as a road to high-value exports, a dynamic food industry and a recognition that "personalised food" was the future.

Dr John Keniry AM FTSE, agricultural producer and company director, emphasised the role of Asia in projected demand and market growth, with world food demand rising by 30 per cent over the next 50 years.

He said that, as a relatively small supplier, Australia should concentrate on higher-margin products, targeting wealthy consumers willing to pay for sustainability, nutrition and food

traceability, while identifying the appropriate niche markets.

He noted that Australia did not have unlimited production potential. It farmed as much of southern Australia as sustainable and was losing land to urban development and climate variation. Northern Australia, which had good land and water, was hampered by transport and infrastructure issues.



delegates the opportunity to meet with key Parliamentarians to discuss their research. Harriet met with Senator Kate Lundy and discussed the importance of technology in supporting innovation in small-to-medium-sized enterprises, particularly through access to high-speed broadband.

The conference reinforced the need for better collaboration between research organisations and business to enable the translation and application of research. It highlighted that encouraging innovation and entrepreneurship was critical to lifting productivity. Supporting greater participation of women in science, technology and engineering was a key theme to the conference discussions.

ATSE was prominent at Science meets Parliament.



ATSE IN ACTION

ATSE analyses Budget impact

ATSE is undertaking a full analysis of the Federal Budget by key National Technology Challenge Areas.

ATSE is pleased to see that initiatives that it has been advocating strongly for with Government have been reflected in the Federal Budget funding – such as the National Collaborative Research Infrastructure Strategy (NCRIS) and the Rural Research and Development Corporations.

But overall, the Federal Budget is mixed for science. It invests in some areas and cuts funding in others, as President Dr Alan Finkel AM FTSE advised Fellows immediately following the Budget announcements.

The Budget cut more than \$400 million from key science agencies over the forward estimates, including CSIRO (\$111 million), DSTO (\$120 million), ARC (\$75 million), ANSTO (\$28 million), Geoscience Australia (\$16 million) and AIMS (\$8 million). Although these agencies actually survived, they will obviously have to make big cuts in their programs – which is not good news.

ATSE regrets the \$80 million cuts to the CRCs program, but is pleased the program was not abolished.

These Budget cuts come after an overall decline in the science budget of \$470 million since 2011 – another indication of the

Government's diminished regard for science and technology, even given the difficult budget situation it faced.

A major concern for ATSE is the decision to wind up the National Water Commission (NWC). This came despite its role in driving water reform in Australia and positioning the nation as a world leader in water management. This is an area where ATSE will be taking action to keep water management as a key platform in the management of our natural resources.

ATSE is concerned about the overall cut in the incentives to translate research into economic benefits for Australia through innovation and commercialization, and also the lessened focus on low-emissions energy technology.

These are two areas where the Academy will also maintain its endeavours to have Government recognise them as vital to our national economic health and prosperity.

Science agenda

Australia's Chief Scientist Professor Ian Chubb was concerned about the impact these reductions could have on our overall capacity in science, while applauding the Medical Research Future Fund.

"Building a stronger, more prosperous Australia requires us to commit to a long-

term science agenda. A resilient advanced economy requires great research, skilled people, competitive technology and adaptive industries," he said. "They are all connected and a decent strategy would make sure that they are connected better than ever. I look forward to working with the Government to develop an action plan for science that will position Australia to advantage."

Water

Water Services Association of Australia (WSAA) Executive Director, Mr Adam Lovell, and Australian Water Association (AWA) Chief Executive, Mr Jonathan McKeown, said the NWC decision was disappointing given the NWC has achieved a great deal in providing national leadership and administering the National Water Initiative (NWI), Australia's blueprint for water reform.

"Abolishing the National Water Commission will weaken our ability to engage Australians on water management challenges through future droughts, floods and with population growth."

CRCs

"Obviously it is bad news," said CRC Association CEO Dr Tony Peacock. "I hoped we had done enough to show the Government

Regulating ourselves into "industrial decline"

Government is 100 per cent dependent on the success of business and should act accordingly, but Australia is regulating itself into industrial decline.

These were two of the hard-hitting messages from Dr Chris Roberts FTSE, CEO of Cochlear Ltd, who addressed a recent ATSE NSW Division luncheon on how Australian companies could remain globally competitive.

Dr Roberts, one of Australia's foremost innovators, spoke of the challenges facing manufacturing in Australia and opportunities for the future. Drawing lessons from the 32-year history of Cochlear, Dr Roberts demonstrated the importance of continued innovation and the tireless pursuit of



technological excellence, citing the need for manufacturing to be multidisciplinary, continually innovative, agile and flexible.

Key points made by Dr Roberts included:

Cochlear's Dr Chris Roberts addresses the ATSE lunch.

- many Australians don't understand the importance of business;
- technological innovation is the turbo-charger of growth, yet it is poorly appreciated;
- Australian industry needs to be fast-moving and better at what it does;
- inertia kills off innovation and must be overcome;
- close collaboration between industry and academia leverages excellence in both;
- big hurdles facing manufacturing in Australia are the regulatory burden and slow approval times, as well as outmoded industrial relations and a rigid labour

ATSE IN ACTION

the value of the CRCs, and I do believe they understand its value. CRCs deliver applied research that has been demonstrated to boost GDP."

The future of the program will be determined following a review, which was already scheduled to be conducted this year.

"The coming review will be critical to our future," said CRC Association Chairman Mr Tony Staley AO. "Every time we have been reviewed in the past, we have shown that cooperative, large-scale collaboration with the end-users in the driver's seat is effective. Seeing the amazing outcomes from the current CRCs, I'm confident we can show that value to the Government."

Infrastructure

While the \$11.6 billion infrastructure investment package was strongly welcomed by the engineering profession, Engineers Australia cautioned that historical fluctuations in Australia's skills base casts a cloud of doubt over our ability to deliver.

"Australia is having real problems retaining skilled engineers in its workforce, with over 40 per cent of qualified engineers now working in jobs outside of the engineering profession. With 27 straight months of national decline in engineering job ads, we need to reinvigorate the engineering sector, and any infrastructure spend is welcome news," said Engineers Australia Chief Executive Officer, Mr Stephen Durkin.

Renewable energy

The scrapping of the Australian Renewable Energy Agency (ARENA) is a backwards step for Australia's drive to develop innovative new renewable energy technologies, and for Australian and international companies who have been working to bring investment to Australia, according to Clean Energy Council Deputy Chief Executive Mr Kane Thornton.

"A global race for renewable energy is on, and the removal of ARENA will see potential Australian and international investors now look to countries with much stronger support for renewable energy innovation, meaning we may well miss out on billions of dollars of investment and highly-skilled jobs," Mr Thornton said.

Climate

The Budget shifts the burden of reducing emissions to taxpayers, while slashing key climate and clean energy programs and independent agencies, according to Mr John Connor, CEO of the Climate Institute.

"It's an attempt to undo the good progress Australia has made recently in cutting carbon pollution, growing renewable energy jobs and taking advantage of our abundant solar, wind and other renewable resources."

Medical research

The Academy of Science welcomed the target to double National Health and Medical Research Council (NHMRC) spending by 2022, new spending on the Future Fellowships program

for mid-career researchers, additional support for the agricultural R&D Corporations and the continuation of the National Collaborative Research Infrastructure (NCRIS).

"While the new Medical Research Future Fund provides a positive vision, the rest of Australian science is left substantially weakened," said Academy President, Professor Suzanne Cory AO FRS FAA.

"We need to increase our science investment now and grow it for decades to come. The commitment to medical research needs to be matched in the rest of the science sector or we will not be able to meet Australia's big challenges."

Scientists

"Scientists welcome the establishment of the Medical Research Future Fund, but are concerned that other cuts across the sector are likely to affect Australia's capacity to continue to produce the world-leading researchers needed to capitalise on such a research fund," said Science and Technology Australia President Dr Ross Smith.

"We understand the need for efficient investment of taxpayers' dollars – and we stand ready to work with government and industry to drive a prosperous future. But reducing our effort to minimise the mid-career brain drain and not investing in a diversity of research capacity risks our ability to innovate across our economy and the foundation of our future competitiveness with other developed nations."

market; and

- the benefits of manufacturing in Australia are that R&D and engineering can be readily integrated with manufacturing, and its safe and high-quality living and working environments.

Successful evolution of Australia's manufacturing industry in a fast-moving, interconnected and competitive world would hinge on Australia's commitment to STEM education, an entrepreneurial culture, adequate capital, government incentives and a regulatory regime that encouraged innovation, he said.

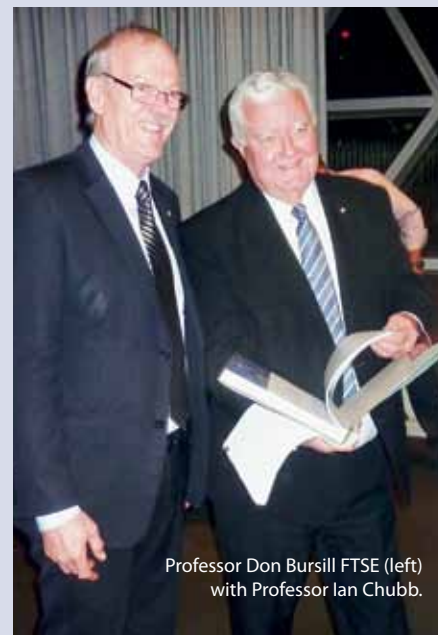
ATSE's NSW Division, in collaboration with the University, Union and Schools Club of Sydney (UUSC), is hosting a series of lunchtime presentations by industry leaders on key issues facing Australia.

SA FELLOWS MEET CHIEF SCIENTIST

The SA Division of the Academy arranged a 'Meet and Greet' opportunity for its Fellows with Australia's Chief Scientist, Professor Ian Chubb AC, prior to him giving a lecture entitled 'The Importance of Science to Australia's Future' in May. The lecture was held in the newly opened South Australian Health and Medical Research Institute.

Fellows had the opportunity to informally discuss recent science developments, particularly the Budget, with Professor Chubb.

At the conclusion of his formal lecture, the South Australian Chief Scientist, Professor Don Bursill FTSE, presented Professor Chubb with a copy of *The Waite: A social and scientific history of the Waite Agricultural Research Institute* by Lynette Zeitz.



Professor Don Bursill FTSE (left) with Professor Ian Chubb.



A Ngara antenna – implementing the CSIRO Ngara breakthrough wireless technology.

'Peak data' threatens our communications

The threat of 'peak data' and what that could mean for the way we connect and access essential services in the future is the focus of a report released by CSIRO.

The report, *World Without Wires*, points out that wireless communications rely on the availability of radiofrequency spectrum. The spectrum has practical limits and more spectrum cannot be created, so we are faced with a finite resource and growing demands to use it.

Today's technologies and infrastructure will be hard-pressed to support further increases in demand, both in terms of speed and volume, for wireless data and services over the coming decades, it says.

Many global cities, including in Australia, are fast approaching the point of 'peak data' – where user demand for wireless internet, telephony and other services can no longer be fully accommodated by the available radiofrequency spectrum.

Wireless technology has been adopted at "breakneck pace" in Australia and around the world, says the Director of CSIRO's Digital Productivity and Services Flagship, Dr Ian Oppermann FTSE.

"The data rates that people now expect from their mobile services are about a hundred times the amount we thought possible only two decades ago," Dr Opperman says.

"Currently the useable spectrum is divided up and allocated to various uses, such as TV/radio broadcast, emergency services and mobile phone communications for example.

"In the future, how spectrum is allocated may change and we can expect innovation to find new ways to make it more efficient, but the underlying position is that spectrum is an increasingly rare resource.

"Some estimates suggest that spectrum demand will have almost tripled by 2020, and existing infrastructure will need to rapidly expand its currently available capacity if it's to meet this demand.

"With more and more essential services, including medical, education and government services, being delivered digitally and on mobile devices, finding a solution to 'peak data' will become ever more important into the future."

World Without Wires examines the role that ubiquitous access to high-speed wireless connectivity will play in enabling a range of future applications and social developments, including:

- the replacement of digital TV and telephony services by internet-based, personalised streaming services;
- widespread sensing technologies that optimise and improve almost every aspect of our daily lives;
- the widespread use of wireless positioning technologies, from making driverless cars the norm to enhancing retail experiences through 'virtual concierges';
- 'tele-services' as the default model of service delivery for government and businesses, with education, health care and other public goods being delivered via private digital networks; and
- a radical improvement in the way existing wireless infrastructure accommodates ongoing growth in service demands, including smaller cells, smarter antennae and beyond.

"Such developments will have a profound impact on both Australia and the rest of the world, constituting significant market opportunities, and a chance to deliver widespread public good from our wireless research and enterprise community," Dr Oppermann says.

World Without Wires is available at www.csiro.au/wireless



Ian Opperman

UPDATED PEST APP FOR SMARTPHONE USERS

The Invasive Animals Cooperative Research Centre has released an updated version of a popular free smartphone app to help people identify Australia's worst pest animal species.

The Field Guide to Pest Animals app, initially released in mid-2013, now provides iOS mobile device users with information about 53 of Australia's worst pest animals, the damage they cause, how to identify them in the field and what control techniques are available. An android version is being considered.

"Australia has more than 80 vertebrate pest species, the main culprits costing at least \$1 billion annually in economic, environmental and social impacts," says Mr Andreas Glanznig, CEO of the Invasive Animals CRC.

Some of the resources accessible through the app include species factsheets, case studies, web-mapping services and standard operating procedures for pest control.

WOMEN IN TSE

Physicist joins elite academy

Scientia Professor of Physics Michelle Simmons FAA has been elected a member of the American Academy of Arts and Sciences, joining great names of science including Stephen Hawking, Albert Einstein and Alexander Graham Bell.



Michelle Simmons

Professor Simmons is a world leader in the field of quantum computing. She is the director of the Australian Research Council (ARC) Centre of Excellence for Quantum Computation and Communication Technology at the University of NSW and was last year awarded an ARC Laureate Fellowship.

Professor Simmons harnesses the power of atoms to develop super-fast, super-small devices that can process huge amounts of data. The ultimate aim of researchers in this field is to develop a commercially viable quantum supercomputer that can complete in days extraordinarily complex tasks that currently take decades. Her research group at UNSW developed the world's smallest working transistor, a crucial component of a future quantum computer. The research was published in *Nature Nanotechnology* in 2012, marking a technological achievement 10 years ahead of industry predictions.

Professor Simmons was awarded a QEII Fellowship in 1999 and came to Australia from the University of Cambridge to be a founding member of UNSW's Centre of Excellence for Quantum Computer Technology.

Over the past decade, her list of achievements and accolades has continued to grow. In 2005, she was awarded the Australian Academy of Science's Pawsey Medal and, in 2006, became one of the Academy's youngest fellows. *COSMOS* magazine named her one of Australia's top 10 scientific minds under 45 and she was also listed among the *Sydney Morning Herald's* 100 most influential people. In 2012, she was named NSW Scientist of the Year.

Professor Simmons has published more than 350 papers in refereed journals, including *Science*, *Nature Nanotechnology* and *Nature Physics*. In the past fortnight she has had papers published in *Nature Materials* and *Nature Nanotechnology*.

The American Academy of Arts and Sciences is one of the oldest and most prestigious honorary societies in the US and a leading centre for independent policy research. Since its founding in 1780, it has elected leading "thinkers and doers" from each generation, including George Washington, Benjamin Franklin, Daniel Webster, Ralph Waldo Emerson, Margaret Meade and Martin Luther King Jr. There are currently only 10 Australian Foreign Honorary Members of the Academy.

SEVEN WOMEN LISTED FOR RIRDC AWARD

Seven of Australia's rural women are competing to be named on 24 September as the national winner of the 2014 Rural Industries Research and Development Corporation (RIRDC) Rural Women's Award. The seven finalists – one from each state and the Northern Territory – were selected

based on a project or 'vision' they want to implement that will benefit rural people or rural industries. Each finalist will receive a \$10,000 bursary to help make their project a reality. The Award also provides the state winners and runners-up with personal and professional development opportunities, including access to a network of Award alumni mentors and a company director's course run by the Australian Institute of Company Directors.

The 2014 RIRDC Rural Women's Award state winners and their projects are:

- Annette Reid (Tasmania), who will undertake a study tour to the western US and Canada to explore successful niche market tomato and garlic enterprises;
- Julie Aldous (Victoria) who will promote careers in primary industries and learning opportunities for high school students through local land management placements and the development of partnerships between schools and their rural communities;
- Jackie Jarvis (WA) who will create video postcards showcasing resettled refugees working in agriculture, following on from a program she runs that helps migrants find employment on farms;
- Penny Schulz (SA) will run the National Dairy Challenge, a two-day event attracting small teams from across the country to compete in a range of dairy-related activities including pasture management, cattle judging, cheese/milk tasting, animal selection based on genetic breeding values and milk quality control;
- Dr Amelia Rentz (NT) will develop a rural education program focusing on high-risk diseases of animals that can infect humans, and how they relate to humans and animals in regional northern Australia;
- Lauren Hewitt (Queensland) will look at improving farm profitability through leasehold tenure and rent security – sharing knowledge and improving collaboration between leasehold jurisdictions; and
- Pip Job (NSW) will set up a rural women's training program, 'Positive Farming Footprints', to create a community of women who have the adaptive capacity to manage the challenges of rural life.

RURAL WRITER HAS INTERNATIONAL WIN

Rebecca Jennings, a writer at Coretext, the R&D journalism and communications company, has been recognised internationally as a 'Young Leader' in agricultural journalism. She was the successful Australian nomination for the 2014 IFAJ-Alltech Young Leaders in Agricultural Journalism award, before being selected as one of 10 winners from around the world. She will join a select group of other young rural journalists in an intensive professional development program to be held in conjunction with the International Federation of Agricultural Journalists (IFAJ) annual congress in Scotland in September. Rebecca entered the awards with a series of articles on how Australian grain growers are embracing emerging e-technology in their farm businesses. The articles were published in *Ground Cover*, the Grains Research and Development Corporation publication. Before joining Coretext Rebecca's previous roles included: Livestock Editor for *Queensland Country Life*; Media Manager at AgForce Queensland; and Communication Adviser for CSIRO in Adelaide.

Rebecca Jennings



By John Söderbaum and Peter Taylor

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Supercomputers crucial to medical R&D

The Victorian Life Sciences Computation Initiative (VLSCI) has the world's most powerful supercomputer that is entirely dedicated to supporting life sciences research.

There is considerable discussion in the media about the age of 'big data' and the vital role that supercomputers will play in helping to analyse the vast amounts of data that are increasingly being collected by leading-edge research projects such as the Large Hadron Collider and the Square Kilometre Array.

However, it is probably less well known that Victoria has a supercomputer that provides computational support for life sciences research. That computer is operated by the Victorian Life Sciences Computation Initiative (VLSCI) and is the world's most powerful supercomputer that is entirely dedicated to supporting life sciences research.

The VLSCI is a \$50 million research infrastructure funding initiative to provide supercomputing facilities and resources to support and strengthen research in the fields of life sciences. It was established as the result of an agreement between the Victorian Government, The University of Melbourne and IBM in June 2008.

The aim of VLSCI is to bring about a dramatic shift in Victorian life sciences research, leading to significant achievements and outcomes in medical, health, biological and related sciences.

Late last year VLSCI commissioned ACIL Allen Consulting to evaluate the performance of VLSCI since it began operations. The evaluation examined both the benefits that are already being realised and potential future benefits.

The former included 'researcher' benefits such as publications, collaboration, employment and capacity development. ACIL Allen found that the VLSCI had delivered measurable benefits in all these areas. Both the number and quality of journal articles have increased steadily over time.

Analysis of the publications attributed to research carried on through VLSCI systems reveals that 57 per cent of those

publications were in journals in the first quartile in terms of their impact – that is, in the top 25 per cent of journals in their category (Figure 1). This provides a strong indication that the research projects giving rise to those publications are likely to be highly regarded globally.

The fact that in 2011 and 2012 alone, VLSCI-supported research projects attracted more than \$25 million in Australian and international grant funding supports the view that the quality of outcomes is highly regarded. The figure for 2013 has just been published in the VLSCI Annual Report 2013 and it is \$53 million.

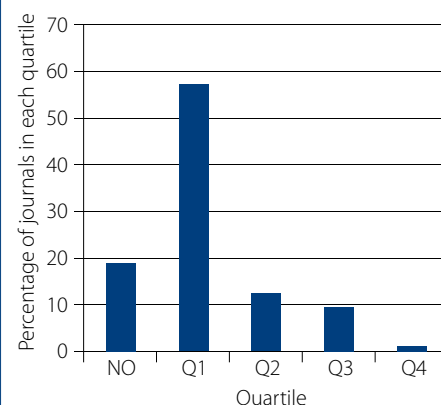
VLSCI was also instrumental in creating additional employment opportunities. The facility also provides a considerable amount of training through its outreach program. In particular, the Life Sciences Computational Centre (LSCC), which was established to assist life scientists without access to the necessary computational skills to use the VLSCI facilities, has regular workshops and seminars to build the careers of the bioinformaticians they employ.

These experts, in turn, are allocated to projects via subscription to the LSCC, which delivers direct access to the systems but also undertakes to build the capabilities of the people in the subscribing institution.

Furthermore, stakeholders noted that the scholarships and financial support provided to students by VLSCI were helping to address the emerging skills required in life sciences to guarantee Victoria's growing reputation as a leading biological sciences hub.

One stakeholder observed that the speed with which discoveries were being made and published as a result of the computational power available through VLSCI was providing a major competitive advantage and helping

Figure 1



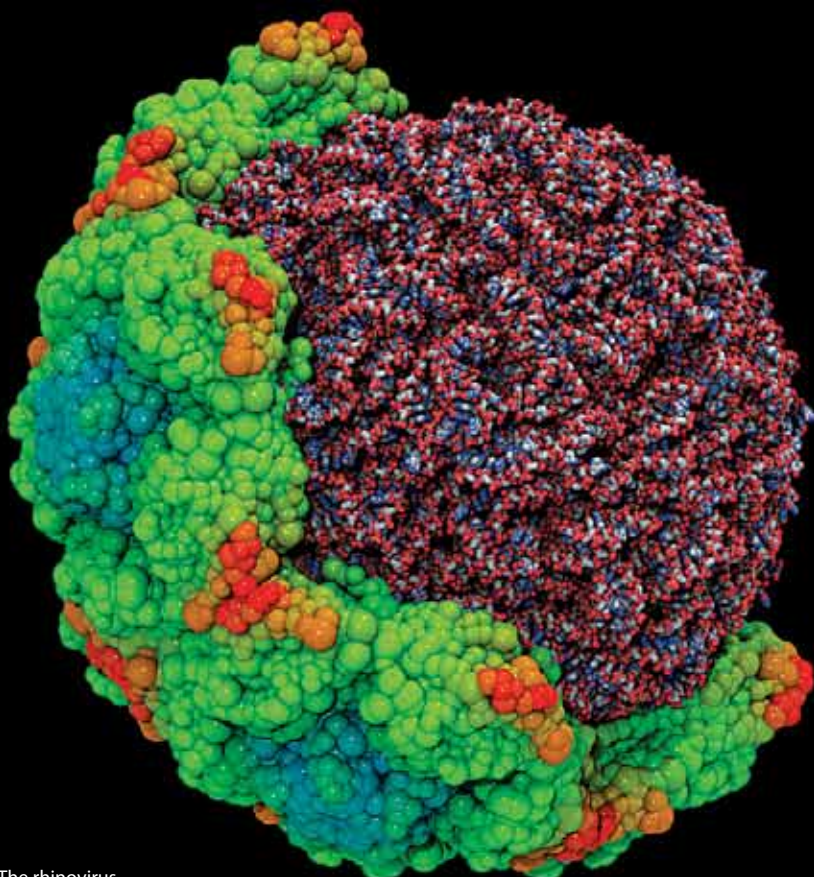
to keep Victoria on the map as a centre for life sciences expertise.

During the course of the evaluation, ACIL Allen identified several projects where VLSCI-supported research results could potentially lead to significant benefits to Victoria, and Australia more generally. Some estimates suggest they could begin to deliver tangible financial benefits to Victoria in as little as 12 months.

One of those projects was led by University of Melbourne researchers, supported by the St Vincent's Institute of Medical Research and IBM. The use of VLSCI facilities enabled the research team to develop the first 3D image of the virus responsible for 40 per cent of colds.

That image is now being used by the research team to better understand how new drugs can block the virus. The results are also being used to better understand other pulmonary conditions for which there are currently no effective treatments, but which cost economies and national health systems billions of dollars per year.

Another project involves a research team at the Peter MacCallum Cancer Centre who have demonstrated that one type of



The rhinovirus.

In 2012, Melbourne researchers from St Vincent's Institute (SVI), the IBM Research Collaboratory for Life Sciences, VLSCI, the University of Melbourne and the Victorian Infectious Diseases Reference Laboratory used Australia's fastest supercomputer to simulate, for the first time, the 3D motion of the complete human rhinovirus, the leading cause of the common cold. At Supercomputing 2012, in Salt Lake City, US, the team, led by Professor Michael Parker, SVI, received a HPC Innovation Excellence Award which recognised their modelling work in the categories of science, engineering, return on investment and potential benefit to society.

IMAGE: DR MICHAEL KUIPER, MOLECULAR MODELLING SCIENTIST, VLSCI

ovarian cancer that is notoriously resistant to conventional ovarian cancer therapy is responsive to treatment with a drug normally prescribed for renal cancer. The research has the potential to allow the classification of cancer according to gene activity and identify where key 'markers' related to specific biochemical pathways cause cancer.

Improved protocols for testing patients for cancer and referring them for treatment is expected to lead to improved patient outcomes, which in turn will, over time, help to reduce the cost burden of cancer on the Victorian economy.

ACIL Allen estimated that the potential economic cost of uterine, ovarian and cervical cancer to the Victorian economy alone could be as much as \$1.15 billion in 2013. It is therefore not difficult to see how improved diagnosis and treatment of these cancers could generate considerable economic benefits.

Measuring the return on investment for significant infrastructure projects such as the VLSCI is complicated. However, we are encouraged by recent serious endeavours to do just that by the high-performance computation community. For example, the

International Data Corporation's Financial Return on Investment and Innovation from HPC Investments pilot study was reported on at Supercomputing 2013 in Denver.

By all measures applied by ACIL Allen, VLSCI appears to offer significant returns on investment. It makes sense that the final recommendation was that VLSCI should increase its outreach to the private sector and become more national in its focus.

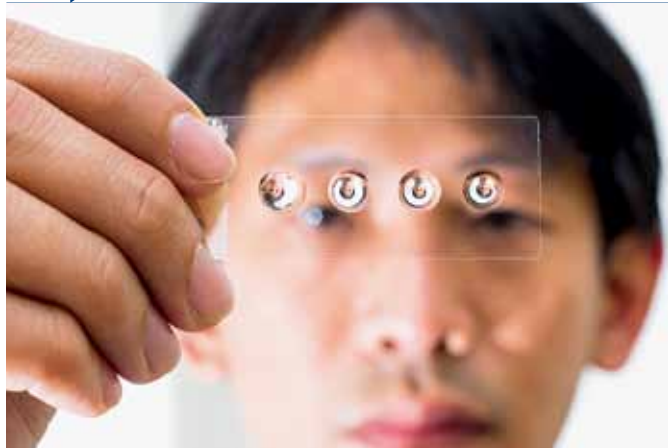
Doing so will be crucial to ensuring the ongoing sustainability of the facility and Australian life sciences research.

Report at <https://www.vlsci.org.au/sites/default/files/ACILAllenreport19Nov2013.pdf>



DR JOHN SÖDERBAUM FTSE is the Director Science and Technology for ACIL Allen Consulting. He provides policy and strategic advice to the private sector, governments and international organisations. He was the project director and lead author of ACIL Allen's evaluation of the VLSCI. He is vice chair of the ATSE Energy Forum and a member of the ACT Divisional Committee.

PROFESSOR PETER R TAYLOR is the Director, VLSCI, and he concurrently holds a joint appointment with the University of Melbourne's Department of Chemistry, acknowledging his research career as a computational chemist. He has contributed to a number of molecular electronic structure codes that are in wide use worldwide. His interests include the maximisation of the benefits high-end computing can bring to research in the discipline sciences, and how such resources can most effectively be deployed.



The droplet microscope.

PHOTO: STUART HAY, ANU

Smartphone a microscope?

Australian scientists have invented a simple and cheap way of making a high-powered lens that can transform a smart phone into a high-resolution microscope. Costing less than a cent, the lenses promise a revolution in science and medicine in developing countries and remote areas.

The lens fabrication technique was invented by Dr Steve Lee from The Australian National University (ANU) Research School of Engineering, who collaborated with Dr Tri Phan from Sydney's Garvan Institute of Medical Research to find ways to transform the lentil-sized lens into a medical imaging tool.

The lenses are made by using the natural shape of liquid droplets.

"We put a droplet of polymer onto a microscope cover slip and then invert it. Then we let gravity do the work, to pull it into the perfect curvature," Dr Lee says. "By successively adding small amounts of fluid to the droplet, we discovered that we can reach a magnifying power of up to 160 times with an imaging resolution of four micrometers."

The first droplet lens was made by accident. "I nearly threw them away. I happened to mention them to my colleague Tri Phan, and he got very excited."

Dr Lee and his team worked with Dr Phan to design a lightweight 3D-printable frame to hold the lens, along with a couple of miniature LED lights for illumination, and a coin battery.

Dr Phan says the tiny microscope has a wide range of potential uses, particularly if coupled with the right smartphone apps. Dr Lee says the low-cost lens has already attracted interest from a German group interested in using disposable lenses for tele-dermatology.

"There are also possibilities for farmers," Dr Lee says. "They can photograph fungus or insects on their crops, upload the pictures to the internet where a specialist can identify if they are a problem or not."

UNIVERSITIES CAMPAIGN TO KEEP IT CLEVER

A 'Keep it Clever' public awareness campaign launched in April by Universities Australia aims to "turbo-charge a national conversation about the role of university education and research in creating the economy of the future".

The campaign uses animation and includes a web film and digital, print, outdoor and national television advertising. It is themed 'Keep it Clever, so Australia does not get left behind'.

Chief Executive of Universities Australia Belinda Robinson says that success in making the economic and industrial transition from where

we are today to the economy of the future demands a strong Australian university sector.

"Underpinning every successful nation is a highly capable university education and research sector," Ms Robinson says. "The economy of the future is dependent on universities producing graduates with the right skills. It will rely on university research creating the new products, industries, technologies and finding solutions to problems that we are even yet to identify."

Universities employ more than 110,000 people and directly contribute more than \$23 billion to GDP.

NEW ANTIVIRALS CLOSER WITH WORLD-CLASS LAB

The Biosecure Immunology Laboratory in Victoria aims to improve Australia's ability to develop new treatments for highly infectious viruses such as influenza and Middle Eastern Respiratory Syndrome (MERS).

CSIRO and Deakin University officially opened the new high-tech national research facility, located inside the Australian Animal Health Laboratory (AAHL) in Geelong, in May.

Dr Kurt Zuelke, director of AAHL, said the new laboratory would provide more specialised techniques at a cellular level to help pinpoint the immune mechanisms employed by various animal hosts.

"This new world-class facility will be critical in helping us develop new, more natural therapeutics and boost our work in preventing, detecting and treating emerging infectious diseases," Dr Zuelke said.

"Researchers in Geelong are already world renowned for their work with zoonotic agents – those that can pass from animals to people – and with this new facility we can now compare the immune responses of different animal species, including humans, to the most pathogenic infectious agents," he said.

By understanding how pathogens affect different hosts, for example, how pigs or poultry protect themselves from influenza, researchers hope to harness a host's successful immune mechanisms to develop new therapeutic approaches to manage these viruses.

The new laboratory is equipped with state-of-the-art equipment, thanks to a long-standing collaboration between CSIRO and Deakin University, with input from the University of Georgia, in the US. It will be made available as a national resource with operational funding support from the National Collaborative Research Infrastructure Strategy (NCRIS).



AAHL immunology researcher Matt Bruce loads a sample into the cell sorter to isolate virus-fighting cells.



(From left) ANSTO Program Director Mr Andy Garcia, Industry Minister Ian Macfarlane, Mr Craig Kelly MP and Dr Adi Paterson inspect the facility commencement works.

Radiopharmaceuticals production to triple

Australia is set to become a global, high-end manufacturer of nuclear medicines used to diagnose cancer and heart disease, with early work now beginning on a new \$168 million nuclear medicine facility at the Lucas Heights campus of the Australian Nuclear Science and Technology Organisation (ANSTO).

Early siting works have started on the facility through which Australia will triple production of molybdenum-99 (Mo-99), which becomes a nuclear medicine called technetium-99m (Tc-99m) in hospitals and medical centres, and is used for diagnosis of cancers, heart disease, muscular and skeletal conditions. It is estimated that Mo-99 is used in about 45 million procedures worldwide every year, with demand continuing to grow particularly in the Asia-Pacific region.

The facility includes a nuclear medicine manufacturing plant and a waste treatment plant to treat by-products for permanent, safe storage at a national waste repository. The project is worth \$168.8 million and, subject to required approvals, the plant will be operational from late 2016.

ANSTO CEO, Dr Adi Paterson FTSE, said Australian leadership was being demonstrated through expanding its important medical role and helping to meet world demand for vital nuclear medicine supplies.

"Through this project, we are saying to the world that Australia is set to become a global leader in the high-end manufacturing of nuclear medicines, and will be able to meet a global supply with proliferation-proof medicine produced with low-enriched uranium," Dr Paterson said.

CARS THE BIGGEST WORKPLACE KILLERS

More workers die in motor vehicles than any other workplace incident, according to Queensland University of Technology's Centre for Accident Research & Road Safety – Queensland (CARRS-Q).

"In the past 10-year period, every year, the motor vehicle killed more people than any other mechanism of injury in the workplace, with 46 per cent of Australian workplace fatalities being vehicle-related," says CARRS-Q research fellow Darren Wishart. "The next two highest killers are being hit with a moving object (12 per cent) and falling from a height (11 per cent)."

Mr Wishart says that in the modern work environment, the vehicle is an extension of the office and, under relevant legislation, was considered a workplace.

"Work-related road safety is a complex issue comprising many

components, therefore to address it any initiatives need to be inclusive of the driver, employers, organisation, family members and the environment."

Vehicle safety is one of the topics to be discussed at the Occupational Safety in Transport Conference (OSIT) to be held on the Gold Coast on 18 and 19 September, which will bring together experts from all facets of transport safety including roads, rail, fleets, and mining to improve workplace health and safety.

CHEWING SCIENCE COULD MAKE FOOD HEALTHIER

Our favourite foods could taste just as good but be healthier in future, thanks to new technology that is revealing the science of chewing.

CSIRO's 3D mastication modelling is starting to provide researchers with new understanding of how to reduce salt, sugar and fat in food products, as well as how to incorporate more fibre and nutrients, and even how to create new food sensations.



CSIRO's 3D computer modelling reveals a healthier future for our favourite foods.

CSIRO biomechanical engineer and computer modeller Dr Simon Harrison says the world's first 3D dynamic virtual mouth can provide detailed insight for developing healthier foods.

Dr Harrison modelled a caramel-filled Easter Egg to see what happened when the virtual mouth takes a bite. "In polite company, we can't see inside someone's mouth while they're eating and, until now, it has not been possible to view how the chewing process alters food," he says.

"Using a cutting-edge technique called smooth particle hydrodynamics, we've developed a virtual mouth built on real data about the physics of chewing. It predicts how a particular food breaks down and how flavour is released in the mouth. It also shows the distribution and interaction of components such as salt, sugar and fat.

"Through this technology, we can view and analyse how food at the microscopic level works in the mouth and how it influences our taste perception."

This new data and understanding is helping to develop foods lower in salt, sugar and fat without changing the taste.

By Martyn Jeggo
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Livestock biosecurity: we need to do better

Australia should seek international research partnerships to better manage the risks from exotic diseases and address lost productivity due to endemic disease.

Livestock keeping has been an essential component in the development of mankind and produce from animals (for example, meat, milk, fur and leather) has been a basic part of our lives.

Over the years the way we keep livestock and utilise their products has changed dramatically but they remain part of our lives in numerous ways.

Managing animal health has always been a key activity associated with keeping livestock, and while this too has changed enormously, it remains a critical aspect for the successful farming of livestock.

Now termed 'livestock biosecurity', the successful control of the major infectious diseases that affect livestock has moved from an individual animal or farm activity to one involving countries, regions and even the world. The successful eradication from the world of cattle plague (rinderpest) in 2011 demonstrated what can be achieved and, given the resources that were required, the importance we attach to livestock diseases.

For many years, the cost of livestock disease has been associated with two major factors: the direct cost of the disease to the animal (whether death or productivity losses) and loss in trade due to the presence of the disease on

the farm or in the country. These two factors have been the major drivers of the elimination of most livestock diseases.

In the past 10 to 20 years, we have seen a major change in our understanding of the risks from animal disease. For example, 75 per cent of new and emerging infectious diseases we see in humans arise in animals, usually wildlife, and there is a global appreciation that the risk from such diseases is seriously increasing.

We now realise that the health of humans is intrinsically linked to that of animals and that the ecosystems in which we live both affects, and is affected by, this relationship. This leads on to the concept of 'one health' and the need to coordinate and collaborate health management of humans, animals and our environment.

Biosecurity positives

Australia has a world-class system for dealing with livestock biosecurity risks, which helps us maintain our enviable status of freedom from the major infectious diseases of livestock. Our systems for early detection of disease incursions and a tried and tested system for response are now built around the Emergency Animal Disease Response Agreement (EADRA) managed by Animal Health Australia (AHA).

Management of EADRA is central to AHA activities. This underpins Australia's capacity to prepare for and respond to a major livestock disease event such as foot-and-mouth disease. This cost-sharing response agreement was established some 16 years ago and both EADRA and the model of AHA are world-first initiatives, highly regarded internationally.

Critical to, and intrinsically linked to, EADRA are detailed plans (AUSVET Plans) for each major disease threat, which not only describe in detail how to identify and confirm a disease outbreak, but who should respond and how. The whole system, including these detailed plans, is continually being improved and tested, with new innovations being introduced where appropriate (for example, the National Livestock Identification System, NLIS, is linked to training programs).

AHA also facilitates a wide range of partnerships and assists collaborative programs between governments and industry that improve animal health, food safety and quality, market access, animal welfare, livestock productivity and national biosecurity – safeguarding confidence in the safety and quality of Australia's livestock products in domestic and overseas markets.

NATIONAL WATER BANK PROPOSED

A leading water scientist has proposed the development of a National Water Bank – a continent-wide replenishment scheme for underground reserves of fresh water – to help safeguard the nation from water scarcities for centuries to come.

The creation of a National Water Bank, a vast monitored network of 'underground dams', could do much to help Australia avoid future water shortages, says Professor Craig Simmons, the Director of the National

Centre for Groundwater Research and Training.

Professor Simmons says a National Water Bank would help by ensuring the nation's aquifers were recharged during times of plentiful rainfall, and then monitoring the water balance of both surface and underground water to ensure adequate future supplies for industry, cities and the environment.

"Like a financial bank balance, the idea of a National Water Bank means being able to know, at any given time, how much you have on hand, and what are your deposits and withdrawals. It is vital we better understand our national groundwater storage capacity, its recharge rates,

PHOTO: 123RF.COM



Animal Health Australia (AHA) is a not-for-profit company that fosters innovative collaborative partnerships involving its members – the Australian, state and territory governments, major terrestrial livestock industries, and service and research suppliers. These partnerships strengthen and improve the national animal health system to ensure competitive advantage and market access, and, significantly, are often achieved through a more effective sharing of available and finite resources.

Through these and other partnerships, Australia has systematically worked also to reduce the burden from endemic disease through robust eradication (for example, tuberculosis, brucellosis) and control programs (for example, bovine and ovine Johne's disease, Newcastle disease) – ensuring that the livestock industry can remain competitive through reducing productivity losses associated with ill health.

Biosecurity negatives

Regrettably, agriculture in Australia receives the least government support of any country in the developed world. This is despite the significant contribution that agriculture makes to GDP, with farm production valued at more than \$50 billion, food retailing at around \$140 billion and more than 500,000 people employed in this sector.

While animal health may not be a priority for investment, it is estimated that a foot-and-mouth disease outbreak

in Australia could cost upwards of \$40 billion. In this situation a modest investment to ensure this remains a low risk, or that a cost-effective response can be mounted in the case of an incursion, would seem a reasonable investment. In a recent Commonwealth Government issues paper an increased investment of some \$20 million was been proposed for biosecurity. What this is to cover and how this has been determined is unclear, but given the range of biosecurity issues, on first glance this would seem woefully inadequate.

The threats to our livestock industry are not just about productivity losses, but the obvious trade embargoes that occur when a new disease occurs in Australia – something that is more likely in the future, as the global risk from infectious disease increases. While the current biosecurity situation in Australia was founded and built on good levels of investment, on joint partnerships and on consensus, the

current system is under enormous pressure due to an inability to even maintain current resourcing levels – and this in the face of an increasing disease threat.

This increasing global risk from new and emerging infectious diseases is universally acknowledged. The United Nations' Food and Agricultural Organization (FAO) states that:

... urbanization and the growing demand for animal products in developing countries are causing the potential costs of animal disease outbreaks to rise steeply. The threats are very real. Deadly and economically devastating livestock epidemics are growing and there is no doubt that more pathogens are emerging. Government could potentially save billions in disease outbreak costs by stepping up the prevention and control of high impact animal disease, a number of which pose a direct threat to human health.

By any measure we are in a situation of an ever-increasing risk of a major disease

and the potential for us to augment and top up our aquifers with artificial recharge," Professor Simmons says.

TURNING BAUXITE RESIDUE INTO HEALTHY SOILS

Researchers from The University of Western Australia, working with Alcoa of Australia, are breaking new ground in ways to transform bauxite residue into healthy soils – a challenging task as they are typically highly alkaline and saline and contain little organic matter, nutrients or microorganisms.

The research team led by Dr Natasha Banning found that adding a combination of green waste compost and fertiliser to the bauxite residue sand improves its rehabilitation potential and its capacity to support plants. The team also investigated how microorganisms behave in bauxite residue sand and their influence on nutrient availability such as nitrogen.

The research has direct application to understanding rehabilitation performance, which can be applied globally to other residue storage areas under a wide range of environmental conditions.

Alcoa of Australia is a major alumina producer globally with three facilities in WA that refine bauxite ore into alumina.

incursion that we simply may not be able to detect in time or respond to effectively.

The challenges associated with existing endemic disease are also serious. Over a number of years Australia has tackled and resolved all those endemic animal health issues that were somewhat easy to manage. What remains are a series of difficult health issues that significantly erode farm productivity and profitability. As an example, internal parasites (worms) cost the livestock sector well over \$50 million a year through productivity losses and treatment costs. Increasingly, drugs that were effective no longer work, yet investment in research in Australia to develop alternatives such as new-generation vaccines is miniscule when compared to such investments in Europe.

And these research investments do bear fruit, as shown by the recent development of vaccine against the barber pole worm (a significant internal parasite of cattle and sheep in Australia) by the Moredun Institute in the UK. If Australia is to remain internationally competitive and increase livestock productivity through reducing further health burdens, then such research investments should be made here.

Human health is dependent on effective management of animal health issues in many areas. Globally, the risk from influenza virus remains high, with the concept ever-present of a virulent avian virus gaining heightened infectivity for humans. The frightening growth in antibiotic resistance is due in part to misuse in animals, while the threat from zoonotic infections, such as those caused by *Salmonella* species and *E. coli*, need to be addressed to maintain consumer confidence in livestock products.

These threats all demand new partnerships between human and animal health professionals. But there is little evidence that this is happening in a meaningful way and their management remains siloed in separate ministries in both Commonwealth and state governments.

The way forward

We are in a fiscally constrained environment, where the modus operandi is to reduce, not increase, government investment. It is imperative that we prioritise, that governments seek partnerships wherever possible (nationally and overseas) and that we seek smart

solutions that deliver tangible and appropriate outcomes for agriculture.

While there are a number of animal health areas that should be specifically addressed, an underlying imperative should be for government to partner with industry to ensure the maximum outcome from available resources and, where necessary, to leverage additional resources.

'One Health' has been defined as "the collaborative effort of multiple disciplines – working locally, nationally and globally – to attain optimal health for people, animals and the environment".

To deliver effectively in the future there will need to be new levels of transparency, a willingness to share and contribute (albeit not always on an equal footing) and the absolute recognition that partnership means joint decision-making. This does not imply that government allow its partners (for example, industry) to dictate policy or interfere with normal government processes and procedures, but does require a recognition that if industry is to invest in joint programs with government, industry will need to be involved in joint decision-making around the allocation and use of such resources. This fundamental principle has without doubt hampered joint resourcing of animal health and biosecurity issues recently, but with the current fiscal situation must be addressed as we go forward.

A robust, transparent and agreed system of prioritisation is urgently needed to assist the process of resource allocation. While the Commonwealth Government's National Biosecurity Committee and its various subcommittees have done much in this area, it has not engaged fully with the various industry and related partners that could assist not only in deciding what requires priority, but in resourcing these areas.

For more than four years, Australia has sought to define what an effective disease surveillance system might look like. Taking into account the need for early detection to allow for a timely and effective response to a major disease incursion, numerous approaches have been debated. Currently we simply do not have an agreed process nor agreed resourcing for what should be a fundamental process for biosecurity. It is proposed that Australia pursue with appropriate national partners, and

through the international organisations FAO and OIE, the development of an agreed international ISO standard for surveillance – something that is currently lacking both internationally and nationally. Such a standard, and adherence to it, should ensure timely detection as well as international trade facilitation in livestock and livestock products.

The threat from exotic diseases continues to grow globally, and endemic diseases continue to limit the competitiveness of the livestock industry both in terms of productivity losses and treatments costs. However, globally a number of important research endeavours using innovative science are beginning to deliver solutions to what have been seen as intractable problems.

Australia should immediately seek international partnerships to undertake critical research to deliver outcomes to ensure that Australia can better manage the risks from an exotic disease excursion and address lost productivity issues due to endemic disease whenever possible.

For those diseases that affect animals and humans and seriously impact our environment, Australia should set up a small One Health directorate to ensure that priority issues are addressed, and that this is done through a genuine partnership between animal and human health professionals, including the sharing of available resources.

Such an approach has already in its infancy in Australia through such arrangements as the Geelong Centre for Emerging Infectious Diseases.

PROFESSOR MARTYN JEGGO FTSE qualified as a veterinary surgeon in the UK in 1972. In 1986 he joined the Animal Production and Health Section of the Joint FAO/IAEA Division to establish a veterinary laboratory support program. For 18 years he worked within the framework of UN programs of support for animal health in the developing world, with research-related projects in some 150 countries. In 2002 he became Director of the Australian Animal Health Laboratory. He retired in 2013 but continues on a part-time basis as the Director of the Australian Centre for Emerging Infectious Diseases, a One Health consortium based in Victoria.



'Botox for plastic' to save power costs

A new material that prevents plastic from ageing has been developed by CSIRO, offering huge potential environmental and cost savings for the energy industry. When applied to plastic lining this 'botox for plastic' can clean up exhaust gases from power plants much more effectively than existing methods.

Currently, the techniques industry use to separate out raw materials such as gases, liquids and solids are extremely energy-intensive, accounting for 40 per cent of the world's energy use each year. According to CSIRO's Dr Sam Lau, the new 'botox' technique offers a solution that will make the separation process a staggering 50 times faster.

"At the moment power generators rely on plastic linings made up of tiny holes just one nanometre wide, a tiny fraction of a width of a human hair," Dr Lau says.

"For decades scientists have been trying to improve the efficiency of this process by using plastics with larger holes. However, these larger openings tend to age very quickly and collapse within a matter of days.

"What we've done is make use of incredible compact materials known as metallic organic frameworks – or MOFs – which have the surface area of a football field in just one gram.

"We found that the density of the MOFs acts like a shot of botox and actually freezes the larger holey structures in place for an entire year."

This suddenly makes the lining with larger holes a viable option for industry, allowing them to complete separation processes 50 times faster.

"This is a much more environmentally friendly approach and of course translates into huge cost and efficiency savings for the companies who take this up."

According to Dr Lau, not only does the technique have incredible potential for cleaning up exhaust gases from power plants, it could also be used to enhance the purity of natural gas streams, the separation of water from alcohols (a key process in biofuel synthesis) and for dye removal in the textile industry.

TRIAL TARGETS 50% BROWN COAL EMISSIONS CUT

CSIRO and its industry partners plan to trial the Direct Injection Carbon Engine (DICE) in Victoria's Latrobe Valley, the second-largest and lowest-cost brown coal resource in the world, with the aim of reducing emissions

Sam Lau holding up a plastic membrane that has received a 'shot of botox'.

from brown-coal-generated electricity by 50 per cent compared to current technology.

Brown Coal Innovation Australia (BCIA) has allocated \$1 million to the technology trial, which is designed to maximise the value of Australia's unique resource by significantly reducing emissions associated with the use of brown coal.

CSIRO Energy Group Executive Dr Alex Wonhas said DICE technology may allow Australia to economically develop coal reserves while reducing the environmental impacts of the sector.

"Australia has the second-largest brown coal resource in the world but current utilisation technologies are carbon-intensive so we need to implement cleaner and more efficient ways to generate energy from coal," Dr Wonhas says.

"CSIRO is excited about the potential for DICE to lower power costs, halve carbon dioxide (CO₂) intensity and create a new export market for both brown and black coal."

The advanced coal technology involves converting coal or biomass into a water-based slurry that is directly injected into a large, specially adapted diesel engine. The fuel burns to produce intense temperature and pressure in the engine, which provides highly efficient power to turn electrical generators.

An existing laboratory-scale prototype engine will trial fuel based on Victorian brown coal and this work will be followed by trials using the same fuel in a large-scale test engine in Japan.

This research will help determine whether DICE can enable brown coal to produce Australia's lowest-cost, reduced-CO₂ electricity for the staged replacement of existing coal power plants.

The project is supported by industry partners including Exergen, Ignite Energy Resources, AGL, MAN Diesel & Turbo and EnergyAustralia. BCIA receives funding from the State of Victoria and the Australian National Low Emissions Coal Research and Development Ltd.

ENGINEERS RATE HIGHLY IN PROFESSIONS SURVEY

The Roy Morgan Image of Professions Survey 2014 confirms the community's ongoing high regard for the engineering profession.

"The Professions Survey – which has been running since 1994 – has rated the engineering profession 'very high' for ethics and honesty for the past two decades," said Mr Stephen Durkin Chief Executive Officer Engineers Australia.

"Of all 30 professions surveyed, engineering rated as the sixth most highly regarded profession in Australia, following nurses, doctors, pharmacists, dentists and high court judges (in order). These findings match our own research; the Engineers Australia Public Awareness Campaign Study 2011 showed Australians view engineering as a trusted profession.

"Our research also showed engineers were trusted, yet paradoxically not very well understood by the community.

"While Engineers Australia is pleased to see the profession remain among the most highly trusted, the organisation believes there is still work to be done in creating a positive stereotype of engineers as creative, innovative, highly skilled and inspiring leaders who have a desire to help others."

By Craig Simmons
director@groundwater.com.au



Australian groundwater: knowledge to help the world



Putting our precious water to use.

PHOTO: ISTOCK

As the world grapples with the problem of providing fresh water to a growing population, Australia has much experience we can share.

If you were asked what the world's most precious underground resource is, you'd probably start listing minerals or petroleum deposits. But it's far more ordinary, and valuable, than any diamonds or barrels of oil.

Groundwater is a life-and-death issue for tens of millions of people around the world. It has a huge influence on whether many nations can continue to grow their economies and feed their people. And, since water scarcity is sometimes a trigger for conflict, it is key to a more peaceful world.

Groundwater sits in porous rocks under the ground. Usually accessed by bores or wells, it is our planet's largest and most precious resource, making up 97 per cent of the world's available fresh water. Total global use is estimated by scientists at about 1000 cubic kilometres a year, which is around 13 times the annual flow over the famous Niagara Falls.

The largest users are India, China and the US. However, Australia is an international leader in the technical art of modelling and predicting the future of groundwater resources, called

hydrogeology. This places us in an enviable position of being at the forefront of global conversations about water scarcity.

Groundwater is already running short in critical regions such as the western US, Mexico, north-western Sahara, Middle East, Indus Basin and North China Plain. This is something everyone who eats should be concerned about because water scarcity affects global food prices for all of us.

Over the past century the world has dipped into its savings account, having drawn down its groundwater reserves by an estimated 4500 cubic kilometres. Meanwhile demand continues to rise, especially in arid and heavily populated countries.

One of the reasons that groundwater is becoming less plentiful is that it is generally managed very poorly. Often we don't know how much we have, or how quickly it can be depleted, or how quickly it is recharged. And we have tended to ignore the unpleasant fact that a large part of it has become contaminated by toxic industrial wastes, rendering the water below many of the world's great cities undrinkable.

In the coming decades, as the climate

changes and human water demand soars, there needs to be a much greater focus on groundwater governance – on putting in place the wisest and best practices for managing this precious resource.

While poor governance has created the problem we now face, good governance, that is both responsible and sustainable, can cure it.

Over the past two years some of the world's largest organisations have joined forces to tackle this issue. *Groundwater Governance – A Global Framework for Action (2011-2014)* is a joint project supported by the Global Environment Facility (GEF) and implemented by the Food and Agriculture Organization of the United Nations (FAO), jointly with UNESCO's International Hydrological Program (UNESCO-IHP), the International Association of Hydrologists and the World Bank.

And Australia plays a valuable role in the Groundwater Governance Project. Ours is one of the very few countries on Earth to have launched a successful bid to reverse a decline in a major

groundwater resource when we capped bores in the Great Artesian Basin.

We are also pioneers in the field of 'water banking' – injecting surface water into underground aquifers during times of plenty, so it can be recovered and used in times of scarcity. And we are international leaders in hydrogeological modelling which is helping us avoid the sort of nasty shocks that have occurred elsewhere when nations have over-extracted water.

In Asia in particular, groundwater now provides around 30 per cent of all the freshwater used; if and when it runs short, it could threaten Asian food security, economic growth and the very existence of many huge cities. Countries where this is happening, like China and India, are keenly aware of the risks but this is not a simple issue to resolve – you can't just turn off the tap.

In south Asia and the nations of the Pacific, thanks to cheap diesel pumps, the unplanned and massive extraction of groundwater over the past 30 years has taxed groundwater reserves in many regions far beyond their ability to recharge or recover. As a result water tables have declined (in some cases by a metre or more each year) causing rivers to dry up.

Much of the Asia-Pacific's economic and population growth occurs in coastal and flood-prone areas and many small island states and countries like Bangladesh, with low-lying deltas and coastlines, are now at risk from rising sea levels, which threaten to contaminate their freshwater aquifers with salt.

Under the great cities all around the world there has been a sustained deterioration in groundwater quality due to ever-increasing use of toxic chemicals and fossil fuels. These leach from landfills, chemical spills, roads and industrial sites and poison aquifers used by city people for drinking water. The Groundwater Governance Project warns that, because groundwater usually moves very slowly, this pollution can be very long lasting and hard to clean up.

For the world to avoid running short of clean, fresh water there is an urgent need for better governance of groundwater and the rapid global sharing of best practices, good laws and regulations, effective policy options, ideas, advanced

technologies and greater public awareness.

Australia has much to contribute in this regard. As a dry country, beset by frequent droughts and surface water shortages, we know how precious water can be and how risky it is to take it for granted.

We understand how it underpins billions of dollars' worth of food and industrial production, as well as our Australian landscapes. We appreciate the importance of prediction and planning to avoid future shortages. As a society, we share a water conservation ethic that is founded on the bedrock of experience.

All these qualities position Australia to play a leadership role in what is now emerging as one of the greatest challenges facing humankind – water scarcity.

As a first-world country with a history of drought and water scarcity, the world

looks to us to set examples and to find innovative solutions. The world expects us to lead and they watch what we do very carefully.

PROFESSOR CRAIG SIMMONS is inaugural Schultz Chair in the Environment at Flinders University and Director of the National Centre for Groundwater Research and Training. One of Australia's foremost groundwater academics, he has been a significant contributor to global advances in the science of hydrogeology for many years and is a member of the Statutory Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development. Professor Simmons' work has been recognised by numerous national and international research and teaching awards including the Anton Hales Medal for outstanding research contributions to the Earth Sciences by the Australian Academy of Science.

WEATHER TECHNOLOGY WINS AWARD

A major upgrade to the Bureau of Meteorology's forecast and warning system has been awarded a prestigious international award.

The Next Generation Forecast and Warning System (NexGenFWS) has enabled a leap forward in the delivery of services. Seven-day forecasts are now available for 650 locations in Australia, a level of service previously only available in capital cities, and a web-based viewer allows people to generate a forecast for a specific location.

The project was named recipient of a Geospatial Technology Innovation Award at the Geospatial World Awards, held in Geneva in May.

The Next Generation Forecast and Warning System has been successfully rolled out in Victoria, New South Wales, Tasmania, South Australia, Western Australia and Queensland. The Northern Territory roll-out later this year will complete the national project.

The Director of the Bureau of Meteorology, Dr Rob Vertessy FTSE, said the award was a credit to the work of many Bureau staff who contributed their expertise to the NexGenFWS project since it began in 2009.

"This award is one of the most prominent peer-reviewed awards in the geospatial industry and recognises the innovative use of geospatial technology," Dr Vertessy said. "In delivering NexGenFWS, the project team has built a forecasting system with the capacity to handle the complexities of forecasting a range of weather such as tropical cyclones, thunderstorms, rainfall, fog and frost.

"The work in presenting this forecast information through interactive maps has enabled the Bureau to develop MetEye, a graphical forecast viewer with a point-and-click interface.

"MetEye brings together the most popular elements of the Bureau's website, displaying seven-day forecasts, satellite and radar imagery, and real-time weather data such as temperature, rainfall, cloud cover, humidity and wind speed."

Dr Vertessy said NexGenFWS and MetEye had been recognised with a number of industry awards since the project began, including the 2013 Asia-Pacific Spatial Excellence Award, presented in April.

Rob Vertessy



ATSE IN FOCUS

AUSTRALIAN ACADEMY OF
TECHNOLOGICAL SCIENCES
AND ENGINEERING

Catherine Livingstone takes chair at BCA

Catherine Livingstone



The Business Council of Australia has elected Ms Catherine Livingstone AO FTSE as its new president for a term of two years.

Ms Livingstone, a Fellow since 2002, is a Director of WorleyParsons Ltd, a Member of the Advisory Board for the John Grill Centre for Project Leadership at the University of Sydney, a Director of the George Institute, a Director of Saluda Medical Pty Ltd, and President of the Australian Museum Trust. She is also a member of the Prime Minister's Business Advisory Council.

Ms Livingstone assumes the role from Mr Tony Shepherd, who has served as president since November 2011.

Ms Livingstone is widely respected in the business community as well as in the not-for-profit and government sectors. She has a wealth of experience in the benefits of science, technology and innovation across all areas of the economy.

Ms Livingstone has been Chairman of Telstra Corporation Ltd since 2009 after previously serving as a non-executive director at the company.

Her career began as a chartered accountant and she has held several roles relating to finance and general management, particularly in the medical devices sector. From 1994 until 2000 Ms Livingstone was the Chief Executive of Cochlear Ltd, during which time she successfully floated the company on the Australian Stock Exchange.

She was Chairman of CSIRO from 2001 to 2006 and delivered the 2012 ATSE Clunies Ross Awards dinner keynote address, which focused on design thinking as a core of innovation.

LEN SCIACCA TAKES ON NEW DSTO ROLE

Dr Len Sciacca FTSE, Chief Operating Officer at the Defence Science and Technology Organisation (DSTO), has been named as Chief, Partnerships and Engagement.

The new role – announced by Dr Alex Zelinsky FTSE, Chief Defence Scientist – will focus on enhancing DSTO's university and industry partnerships and alliances under the direction of Dr Warren Harch, Deputy Chief Defence Scientist, Partnerships and Outreach.

Dr Sciacca will also lead Defence's science communication activities, which will also play a role in communicating the progress and scientific outcomes of DSTO research and the partnership programs.

A key plank of the DSTO Strategic Plan 2013–18 is the Defence Science Partnerships program currently being finalised with universities around Australia. The program aims to align research projects and infrastructure planning between DSTO and universities with key defence science priorities, enhancing research impact and leveraging funding from multiple sources.

DSTO has been working with a number of universities to develop a consistent set of research agreements and pricing models which will reduce overheads in negotiating collaborative research projects and build greater visibility in areas such as

intellectual property, research outcomes and realising opportunities to collaborate and innovate between universities and industry.

The Defence Science Partnerships is based on closer relationship management between DSTO researchers and academics and developing a portfolio of projects in each university. The principles being instilled in the partnership include collaboration with institutions that possess world-class research credentials, the leveraging of funding and alignment of research activities between the DSTO and universities.

An important element of the engagement will be the promotion of science, technology, engineering and mathematics (STEM) through local and national STEM outreach programs. The aim will be to address specific needs in national STEM capabilities including women in science and engineering and the number of Aboriginal and Torres Strait Islanders undertaking careers in STEM.

Dr Sciacca brings to the role a long history of building partnerships, product development and collaborative research nationally and internationally.

He has experience in all parts of the innovation sector having worked in CSIRO, the universities of Newcastle and Melbourne, product and project-based industries and a CRC, as well as establishing his own company, Australian Systems Research, in the mid-1990s.

His engineering and research experience spans real-time computing, large antenna design, servo systems, networked sensors, estimation and adaptive control. He was head of DSTO's Electronic Warfare and Radar Division for six years before becoming DSTO's Chief Operating Officer.

He was Director of the Defence Science Institute in 2010 and has been Chair of ARC College of Experts in Mathematics Information and Computing panel.



Len Sciacca

ATSE IN FOCUS

Maree Smith's work attracts \$48 million for pain drug

An Australian company developing a chronic pain treatment based on research at The University of Queensland (UQ) has attracted \$48 million investment to advance development of the drug, EMA401.

EMA401 is based on research led by Professor Maree Smith FTSE from UQ's Faculty of Medical and Biomedical Sciences.

The deal represents one of Australia's largest off-market investments in a private biotechnology company.

Spinifex Pharmaceuticals Pty Ltd, which was founded in 2005 by UQ's main commercialisation company

UniQuest, has attracted Series C financing from a syndicate of investors, including Danish venture capital firm Novo A/S and US-based investors Canaan Partners.

The funds will be used to progress clinical trials of EMA401 as an oral treatment for neuropathic and

Maree Smith

inflammatory pain, without central nervous system side effects.

Neuropathic pain (a type of nerve pain) affects more than 1.5 million people worldwide. Neuropathic pain and inflammatory pain are most commonly associated with cancer chemotherapy, post-herpetic neuralgia (a painful condition that develops in some patients following shingles), diabetes, peripheral nerve injury and osteoarthritis.

UQ Vice-Chancellor and President Professor Peter Høj FTSE said Professor Smith was an excellent researcher who was determined to ensure that people worldwide would benefit from her work.

"Maree has persevered for many years with a view to ensuring that her research succeeds through the rigorous journey to

market and reaches the people who need it," Professor Høj said.

"This international investment is a tremendous endorsement of her mission, of Spinifex Pharmaceuticals and of the work of UniQuest with fine support from Uniseed.

"The funding reflects a well-founded sentiment that excellent researchers who are part of a purposeful commercialisation strategy can deliver tangible benefits to a vast community."

Spinifex CEO Tom McCarthy said the investment validated the company's world-class drug development capabilities.

"To have attracted significant funding from two of the best-respected investors in global biotechnology is testament to the quality of the science behind Spinifex and our development work on EMA401 supported by our long-term investors."

In 2013, UQ recognised Professor Smith – a Fellow since 2011 – as a Top Five Inventor and Innovator at its inaugural Top Five Inventors and Top Five Innovators awards.

UniQuest is one of Australia's leading research commercialisation companies, specialising in global technology transfer and facilitating access for all business sectors to world-class university expertise, intellectual property and facilities. UniQuest's innovation portfolio includes Australia's first blockbuster vaccine Gardasil®, Australia's largest biotech IPOQRxPharma Ltd, the internationally acclaimed Triple P Positive Parenting Program and UQ's superconductor technology, which is used in two-thirds of the world's MRI machines.

GRAEME DANDY NAMED WATER PROFESSIONAL

Professor Graeme Dandy FTSE was awarded named Water Professional of the Year by the Australian Water Association at its 2014 Annual Conference 'Ozwater14' in Brisbane in April.

The award honours "individuals who have displayed a sustained passion and continued commitment to the water industry and who have demonstrated outstanding leadership and influence in the water sector".

Professor Dandy has been the Professor

of Civil and Environmental Engineering at the University of Adelaide. His interests have included:

- genetic algorithm techniques applied to the optimum design and operations of water distribution systems;
- monitoring, modelling and optimising water quality in water distribution systems;
- use of artificial neural networks techniques for forecasting hydrologic and water resources variables;
- optimum selection of wastewater treatment trains;
- water resources planning; and
- water reuse.



Graeme Dandy

In 2013, Professor Dandy was awarded the 2013 South Australian Premier's Water Medal for his outstanding contribution to the South Australian water industry.

In 2012, Professor Dandy was a co-author of the ATSE Report *Sustainable Water Management: Securing Australia's future in a green economy*.

CATHY FOLEY PRESENTS ON WOMEN IN SCIENCE

The NSW Woman of the Year 2013 and CSIRO scientist, Dr Cathy Foley PSM FTSE, presented a Women in Science seminar at the ANSTO Australian Institute of Nuclear Science and Engineering (AINSE) Theatre in April.

Dr Foley's career at CSIRO has been broad, influential and widely cited. She was appointed Chief at CSIRO Materials Science and Engineering (CMSE) Division in April 2011. Her scientific achievements and highlights of her career include leading the High Temperature Superconductivity (HTS) group in 1995, instigating CSIRO's presence in quantum engineering in 2001, and developing the fabrication technology which is the basis of CSIRO's successful HTS devices.

For the past 28 years she has been actively promoting the role of women in science and physics.

ATSE IN FOCUS

Anita Hill goes upstream at CSIRO

Victorian Division Chair Dr Anita Hill joins the top echelon of CSIRO executives in a reshuffle which takes effect from 1 July.



Anita Hill

She joins the eight-person Executive Team as Executive Director Manufacturing, Productivity and Services, responsible for the Digital Productivity and Services and Future Manufacturing Flagships, as well as the Services line of business, which includes Education, Publishing, Infrastructure Technologies (IRS), SME Engagement Centre and CSIRO Futures.

She will be responsible for the Clayton and Parkville Precinct strategies of CSIRO's major Melbourne operations.

Dr Hill, a Fellow since 2008, is presently Group Executive, Manufacturing, Materials and Minerals, and her work is building Australia's international standing in the field of nanostructured materials and processes.

Dr Hill has experience in senior research and general management roles and has been with CSIRO since 1996.

Dr Hill was awarded a Bachelor of Engineering in 1985 and a Doctor of Philosophy (1989) in Mechanical Engineering and Materials Science, both from Duke University, North Carolina, and began her career at Monash University as a lecturer. She joined CSIRO in 1996.

CSIRO's new operating structure, announced by CEO Dr Megan Clark FTSE, has three lines of business: National Facilities and

Collections; Impact/Science, represented by the new Flagship portfolio; and Services.

Dr Hill will join four other Executive Directors on the Executive Team:

- Dr Dave Williams, who was CEO of the UK's Space Agency and chairman of the European Space Agency before joining CSIRO more than a year ago, will be Executive Director National Facilities and Collections;
- Dr Maurice Moloney, who was Director and Chief Executive of Rothamsted Research in the UK before joining CSIRO in 2013, will be Executive Director Agribusiness, Food and Health responsible for the Agricultural Productivity, Food and Nutrition and Biosecurity Flagships. He will be responsible for the Black Mountain (Canberra) Precinct strategy;
- Dr Andrew Johnson will be Executive Director Environment responsible for the Oceans and Atmosphere and Land and Water Flagships; for coordinating CSIRO's Northern Australia strategy and coordinating its response to the Government on the Northern Australia, Energy and Agriculture white papers. Andrew will be responsible for the Ecosystems Science Precinct in Brisbane; and
- Dr Alex Wonhas will be Executive Director Energy and Resources responsible for the Minerals Down Under and Energy Flagships and the National Resources Science Precinct in Perth.

They will join Ms Hazel Bennett, CFO, and Mr Craig Roy, Deputy Chief Executive Science, Strategy and People, as the Executive Team of the organisation from 1 July, which will reduce the Executive Team from 10 (including the Chief Executive) to eight positions.

LINDSAY FALVEY ANSWERS 10 QUESTIONS

Professor Lindsay Falvey FTSE has published a new book, *Q&A – Beliefs that Bias Food and Agriculture – Questions I'm Often Asked*.

Professor Falvey says the book answers 10 questions addressed to the author in various forms.

"Some are personal, while others relate to global issues. All are answered with candour and detailed explanation.

"The answers will not suit those who seek confirmation of popular viewpoints, nor will they suit those who insist they are doing good without having knowledge of what they are really doing.

"But they will admirably suit those



Lindsay Falvey

extremely important persons from all walks of life who are open to new knowledge, who can accept challenges to their beliefs and received knowledge," he says.

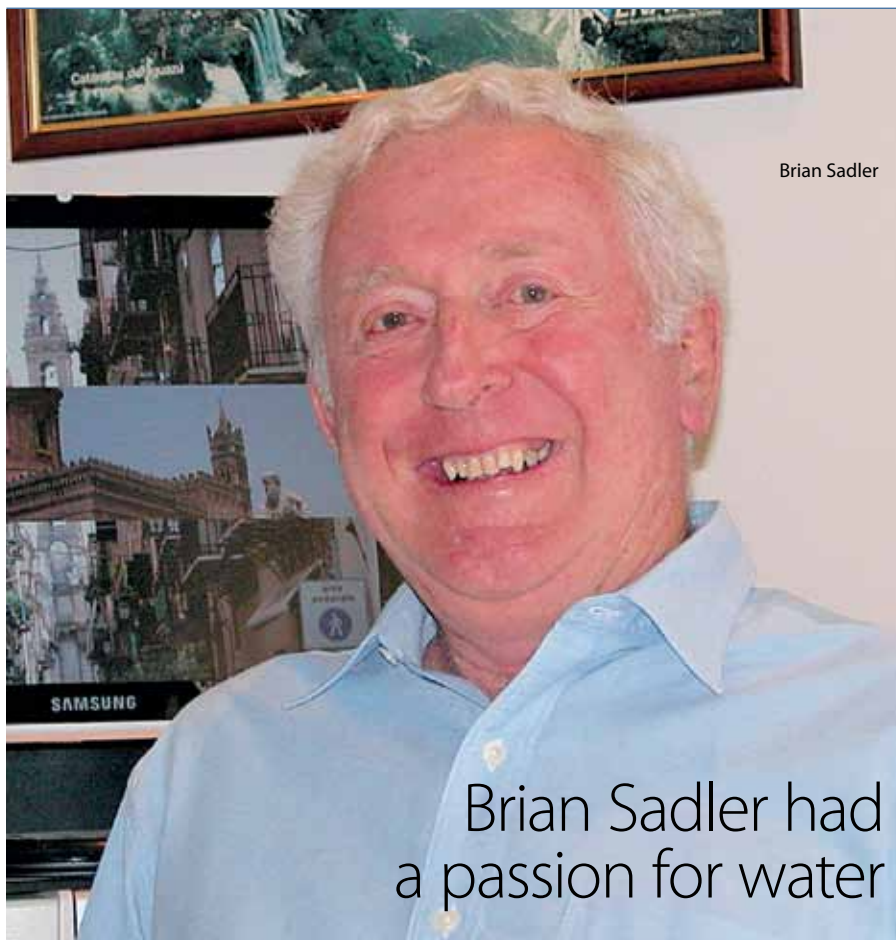
The answers cover a range of topics:

- why livestock are critical to food security;
- why free trade and markets can't solve food shortages;
- why aid shouldn't insist poor countries follow our model;
- how to reconcile science and commerce with popular ideals;
- how gross domestic happiness can be a serious topic;
- how more food can be produced with less land and fertiliser;
- why labels like 'Buddhist' and 'vegetarian' confuse life;
- what traditional wisdom is critical to development;
- how misrepresentation fuels fears about climate change; and
- why small farmers and foreign agribusiness must coexist.



Lindsay Falvey's new book: *Questions I'm Often Asked*

ATSE IN FOCUS



Brian Sadler

Brian Sadler had a passion for water

Mr Brian Sadler PSM FTSE was a stalwart of the Western Australian water industry for more than 50 years, and won national and international recognition for his roles outside WA.

Mr Sadler spent most of his career in the WA Public Service, becoming Executive Director, Water Resources Division, Water Authority (WA) and later Principal Consultant Water Reform for the Waters and Rivers Commission.

A Fellow since 1997, he died in Perth on 25 March, aged 76.

A graduate in Civil Engineering from the University of WA, he joined the Public Works Department of WA in 1960 as assistant resident engineer for the Fitzroy River Barrage construction. Over the next 25 years he held successively more senior roles in the PWD – section manager, project engineer, senior engineer and, finally, Assistant Chief Engineer, Water Resources.

He joined the Water Authority in 1985 as Principal Engineer, State and System Planning, in the Water Resources Planning Branch and progressively served as Manager, Water Resources Planning; Acting Director, Water Resources; Director, Water Resources

Directorate; and Executive Director, Water Resources Division.

In 1997 he was Principal consultant, Water Reform for the WA Water and Rivers commission and since his retirement in 1997 had operated a water policy consultancy.

Mr Sadler's work is best reflected in a eulogy by his friend Robert Harvey, which we reproduce below in edited form.

Some of you would not be aware of the strong international orientation of much of Brian's work.

For 10 years he was Chairman of the UNESCO International working group on the Socio-Economic Role of Water in Society. From this work, he was invited to become the Australian representative at the Middle East Peace Talks from 1993 to 1996 on the working group on water resources. This work was among the highlights of his career.

Brian was close to the action and security was intense. This work took him to Beijing, Muscat, Athens and Amman. His earlier work at UNESCO had already taken him to Buenos Aires, Paris, Stockholm and the USA.

He was a voracious reader on water issues and brought to them his own thinking and integrity. It was a natural outcome that he became

“Brian's work meant much to him. He was passionate about it. He always wanted to “do the right thing” and fearlessly so. ... He was highly regarded by all he worked with.

– Robert Harvey

a founding member of the Editorial Board of the journal Water Policy from 1997 to 2007 for the World Water Council, building political commitment and action on critical water issues internationally. He was also a Member of the Board of Directors, International Association of Public Participation, 1990–97.

Closer to home Brian was Chairman of the Indian Ocean Climate Initiative and for years through the 1980s he was heavily involved with the Australian Water Resources Council in different roles including as Chairman of the Planning Committee, even Chairman of the Chairman's forum.

He was, along with Ken Webster (the late Mr Ken Webster AM FTSE who, as Chairman of the Water Authority, supported Brian's election to the Academy), a major player in conceiving the Western Australian Water Resources Council; and in supporting it to make sure it was an effective instrument in managing the state's water resources. He was, for the Institution of Engineers Australia, Chairman of the National Committee on Hydrology and Water Resources.

He was an early and clear voice in effective planning and response to climate change. He explicitly incorporated into our resource planning varying scenarios of climate change impact, which in turn led to a strategic and early move away from our reliance on surface water to groundwater and subsequently on to desalination.

Brian's work meant much to him. He was passionate about it. He always wanted to “do the right thing” and fearlessly so. He says he developed this passion early in his schooling from the Christian Brothers at CBC Perth. Brian's motive was always to serve the greater public good and never personal gain. He was highly regarded by all he worked with.

Brian operated at a different level to most people – always strategic, always thinking ahead. He travelled extensively during his career. He had a sharp intellect, a confident, friendly nature and a great ability to communicate.

He was definitely one of life's gentlemen. His family and friends will miss him dearly.

– ROBERT HARVEY

ATSE IN FOCUS

Two Fellows join AAS

Two ATSE Fellows have been elected to Fellowship of the Australian Academy of Science.

Professor Rose Amal FAA FTSE, Scientia Professor, School of Chemical Engineering, University of New South Wales (UNSW), was elected "for her outstanding contributions to photocatalysis and leadership in harnessing solar energy to purify water and generate Hydrogen 2".

Ms Catherine Livingstone AO FAA FTSE, Chair of Telstra, was elected "for championing science and technology and the critical role they play in the future development of Australia, and for services to the Australian Academy of Science".

Professor Amal is leader of the Particles and Catalysis Research Group and Director of Research, School of Chemical Engineering,

UNSW, as well as Director of the ARC Centre of Excellence for Functional Nanomaterials. She is also Honorary Professor, Australian Institute of Bio and Nanotechnology (AIBN), at the University of Queensland, and an ARC Australian Professorial Fellow.

Professor Amal has worked in the area of particle technology for more than 20 years, on fine particle aggregation, photocatalysis, nanoparticle synthesis and their applications.

More recently, her research focus has been on the design of photocatalysts and engineering systems for solar induced processes, using the sun's energy as a clean fuel source.

Over the past 10 years, Professor Amal has secured more than \$15 million in grants. She has published extensively in major science and engineering journals, and has strong links with various industry members and public sectors.

Ms Livingstone is widely respected in the business community as well as in the not-for-profit and government sectors. She has a wealth of experience in the benefits of science, technology and innovation across all areas of the economy.

Ms Livingstone is Chair of the Business Council of Australia and has been Chairman of Telstra Corporation Ltd since 2009, after previously serving as a non-executive director at the company.

Her career began as a chartered accountant and she has held several roles relating to finance and general management, particularly in the medical devices sector.

From 1994 until 2000 Ms Livingstone was the Chief Executive of Cochlear Ltd, during which time she

successfully floated the company on the Australian Stock Exchange.

She was Chairman of CSIRO from 2001–06.

Ms Livingstone is a Director of WorleyParsons Ltd, a Member of the Advisory Board for the John Grill Centre for Project Leadership at the University of Sydney, a Director of the George Institute, a Director of Saluda Medical Pty Ltd, and President of the Australian Museum Trust. She is also a Member of the Prime Minister's Business Advisory Council.

CONTROL SYSTEMS WERE JOHN EDWARDS' FORTE

Mr John Edwards had an international reputation for advanced control system design and modelling for industrial processes.

Born in Toronto, near Newcastle, NSW, and with Bachelor's and Master's degrees from the University of Sydney, he spent most of his working life in Newcastle, after working as a research engineer at Imperial College, London.

He worked as a Senior Research Engineer and Assistant Manager, Special Projects, at the Lysaght Research and Technology Centre in the 1970s, before establishing his own business, Industrial Automation Services, in Newcastle in 1981.

A Fellow since 1996, he died in NSW on 13 February, aged 71.

His nomination citation noted that his company "has successfully marketed a complex, highly innovative rolling mill analysis and automation program to 15 countries world-wide", which were used in Australian steel-rolling mills.

The business won NSW and Australian small business awards in 1992.

His nomination said he had achieved a "most outstanding career in research, development and the marketing of created technologies".

Mr Edwards was a Fellow of the Institution of Engineers, Australia, and the Institute of Metals and Materials, Australia, and won the M A Sargent Medal in 1993.

He was active in community affairs in the Newcastle district and was a prominent squash player.



John Edwards



Rose Amal

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